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A Summary of Current Program and
Preliminary Report of Progress

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POTATO RESEARCH

of the

United States Department of Agriculture
and Cooperating Agencies

This progress report of U.S.D.A. and cooperative research is primarily a tool for use of scientists and administrators in program coordination, development, and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of progress on U.S.D.A. and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having an interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of U.S.D.A. and cooperative research issued during the last year. Current agricultural research findings are also published in the monthly U.S.D.A. publications, Agricultural Research, Agricultural Marketing, and The Farm Index.

UNITED STATES DEPARTMENT OF AGRICULTURE

Washington, D. C.

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ADVISORY COMMITTEES

The research program of the Department of Agriculture is reviewed annually by the following advisory committees:

1. Farm Resources Research
2. Utilization Research and Development
3. Human Nutrition and Consumer Use Research
4. Marketing Research and Service
5. Agricultural Economics Research
6. Forestry Research
7. Animal and Animal Products Research
8. Cotton and Tobacco Research
9. Grain and Forage Crops Research
10. Horticultural Crops Research
11. Oilseed, Peanut and Sugar Crops Research

ORGANIZATIONAL UNIT PROGRESS REPORTS

The source materials used by the advisory committees are of two types. First, there are Organizational Unit Reports that cover the work of the Divisions or Services listed below. The number prefixes refer to advisory committees listed above that review all of the work of the respective Divisions or Services.

Agricultural Research Service (ARS)

- 1 - Soil and Water Conservation
- 2 - Utilization -- Eastern
- 2 - Utilization -- Northern
- 2 - Utilization -- Southern
- 2 - Utilization -- Western
- 3 - Human Nutrition
- 3 - Clothing and Housing
- 3 - Consumer and Food Economics
- 7 - Animal Husbandry
- 7 - Animal Disease and Parasite

Agricultural Marketing Service (AMS)

- 4 - Market Quality
- 4 - Transportation and Facilities

Economic Research Service (ERS)

- 4,5 - Marketing Economics
- 5 - Farm Production Economics
- 5 - Resource Development Economics
- 5 - Economic & Statistical Analysis
- 5 - Foreign Development and Trade Analysis
- 5 - Foreign Analysis Division

Other Services

- 1 - Soil Conservation Service (SCS)
- 4,5 - Farmer Cooperative Service (FCS)
- 4,5 - Statistical Reporting Service (SRS)
- 6 - Forest Service (FS)

Three organizational unit reports are not reviewed in entirety by any one committee. All of the information in them is included in the subject matter reports.

Agricultural Research Service (ARS)

Agricultural Engineering
Crops
Entomology

SUBJECT MATTER PROGRESS REPORTS

The second type of report brings together the U.S.D.A. program and progress for the following commodities and subjects:

- | | |
|--|--|
| 1 - Cross Commodity Research of
Agricultural Engineering, Crops,
and Entomology Research Divisions | 7 - Cross Species and Miscellaneous
Animal Research |
| 3 - Rural Dwellings | 8 - Cotton and Cottonseed |
| 6 - Forestry (Other than Forest
Service) | 8 - Tobacco |
| 7 - Beef Cattle | 9 - Grain and Forage Crops |
| 7 - Dairy | 10 - Citrus and Subtropical Fruit |
| 7 - Poultry | 10 - Deciduous Fruit and Tree Nut |
| 7 - Sheep and Wool | 10 - Potato |
| 7 - Swine | 10 - Vegetable |
| | 10 - Florist, Nursery and Shade Tree |
| | 11 - Oilseeds and Peanut |
| | 11 - Sugar |

A copy of any of the reports may be requested from Barnard Joy, Assistant to Administrator, Agricultural Research Service, U. S. Department of Agriculture, Washington 25, D. C.

INTRODUCTION

This report deals with research on the white or Irish potato (not sweet-potato) and covers work directly related to the production, processing, distribution and consumption of potatoes and potato products. It does not include extensive cross-commodity work, much of it basic in character, which contributes to the solution of problems of other commodities as well as those of potatoes. The progress on cross-commodity work is found in the organizational unit reports of the several research divisions of the Department.

This report is organized by problem areas which are shown as the major subjects under the three main divisions in the table of contents. For each of the problem areas there is a statement of (1) the Problem, (2) USDA PROGRAM, (3) REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS for the past year, and (4) PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH.

Research on potato problems is supported by (1) Federal funds appropriated to the research agencies of the USDA, (2) Federal and State funds appropriated to the research agencies of the USDA, and (3) private funds for research carried on in private laboratories or for support of State Station or USDA work.

Research by U.S.D.A.

Farm Research

Farm Research comprises investigations on introduction, breeding and genetics, variety evaluation, culture, diseases, nematodes, weed control, insects, and crop harvesting and handling operations and equipment. This research is conducted by the Crops, Entomology and Agricultural Engineering Divisions of the Agricultural Research Service; and in fiscal year 1963 involved 23 professional man-years.

Nutrition, Consumer and Industrial Use Research

Nutrition and consumer-use research pertains to composition and nutritive value; physiological availability of nutrients and their effects; and new and improved methods of preparation, preservation and care in homes, eating establishments and institutions. This work is done by the Divisions of Human Nutrition Research and Consumer and Food Economics Research of the Agricultural Research Service, and in fiscal year 1963 involved 1.2 professional man-years.

Utilization research deals with methods of preservation of potatoes through canning, drying, freezing, or combinations of these methods and also with the origination of new forms of food products or combinations of potatoes with other foods. It is also concerned with improved equipment and processes. The work is done by the Eastern

Utilization Research and Development Division, Wyndmoor, Pennsylvania; by the Western Utilization Research and Development Division at Albany, California; under contracts with foreign country laboratories; and in cooperation with the industry and other organizations mentioned under Program for each research area. In fiscal year 1963, the work involved about 24 professional man-years.

Marketing and Economic Research

Marketing research involves the physical and biological aspects of assembly, packaging, transporting, storing and distribution from the time the product leaves the farm until it reaches the ultimate consumer. The work reported herein is conducted by the Market Quality and Transportation and Facilities Research Divisions of the Agricultural Marketing Service. Economic research is concerned with market potentials for new products and uses; merchandising and promotion, economics of transportation and storage, marketing costs, margins and efficiency; market structure, practices and competition; information, outlook and rural development; supply, demand and price; situation and outlook; and improving marketing through research with farmer cooperatives. The work reported herein is done by the Economic and Statistical Analysis and the Marketing Economics Research Divisions of the Economic Research Service; by the Standards and Research Division of the Statistical Reporting Service; and by the Marketing Division of the Farmer Cooperative Service. Approximately 15 professional man-years were devoted to marketing and economic research in fiscal year 1963.

Interrelationships Among Department, State and Private Research

Much of the Department's research is cooperative with State Experiment Stations, various sectors of industry and with growers. Cooperative work is jointly planned and frequently participated in by Federal, State and industry workers. The nature of the cooperation varies with each study. It is developed to fully utilize the personnel and other resources of the cooperators. There is regular exchange of information between State and Department scientists to assure that the research programs complement each other and eliminate undesirable duplication. Many Department employees are located at State Stations and use laboratories and office space close to, or furnished by the State.

Privately supported research of considerable extent is done by food processors and distributors, chemical and fertilizer companies, manufacturers of materials handling systems, food industry and trade associations, food container and equipment suppliers, package and container manufacturers, market research institutes and corporations, seed suppliers and growers. Industry's cooperation in supporting research on potatoes in the form of grants, gifts or loans of materials, equipment and facilities at Federal and State stations has contributed greatly to its success.

A number of food processing companies and wholesale and retail distributors are presently conducting research in various phases of products and process development in frozen, canned, and dried potato products. The canning, freezing and dehydrating industries each maintain an association with a technical staff and either do research in their own laboratories or support research at U.S.D.A. laboratories, universities and other organizations. Allied industries and suppliers to the food processing industry maintain excellent laboratories and large research staffs to provide technical information to the industry.

Marketing equipment and facility manufacturers also make sizeable contributions to research on the development of equipment for handling potatoes on the farm, into and out of packing houses, transportation vehicle, wholesale distribution center and in the retail establishment as well as research on the containers in which they are moved and on the transportation vehicles from which they move from one point in the distribution channel to another. Market research institutes and others in marketing economics research are largely concerned with research in consumer preference, market potentials, and interregional and intermarket competition.

Chemical and fertilizer companies are significant factors in research on the development of new materials or combinations of materials to produce more efficiently, high quality potatoes through better nutrition of the growing plant, control of diseases, insects, nematodes, weeds, killing of tops, skin color intensification and protective waxes.

Several of the seed certification associations as well as large private seed producers expend considerable time and money on varietal adaptation experiments and disease tolerance readings that are so necessary to determine the acceptability of standard varieties and the new varieties that appear at frequent intervals from the potato breeders; Federal, State and private. The contribution of growers to our overall research effort on potatoes is substantial. Certainly, in the field of production his help is indispensable for most of the laboratory research results must finally be confirmed by field experiments. The grower cooperates with the U.S.D.A., State Experiment Stations and suppliers of many materials and equipment; usually without compensation except for the experience and knowledge gained.

Example of Recent Research Accomplishment by USDA and Cooperating Scientists

Nondestructive Measurement of Interior Quality of Fruits and Vegetables. Techniques and equipment have been developed for making measurements of the spectrum of light transmitted through intact fruits and vegetables. These measurements have led to the development of methods to measure the maturity of peaches, apples, plums, and other fruits, to detect black-spot of potatoes, water core or other internal disorders of apples, and blood spots in eggs. Methods can be made available whereby the non-conforming specimens are automatically removed from the packaging lines.

I. FARM RESEARCH

POTATO CULTURE, BREEDING
DISEASES, AND VARIETY EVALUATION
Crops Research Division, ARS

Problem. Potatoes are grown in all 50 States and are planted and harvested every month of the year, thereby creating a need for varieties for regional adaptation and specialized uses and markets. New cultural practices necessitated by economic pressures for greater efficiency in production have tended to lower potato quality, creating a need to expand research to find ways of reversing the present trend toward lower potato quality. The increase in potato processing (24.7 percent of the total crop or 47 percent of the tablestock portion of the 1961 crop was processed) has created a demand for new, more suitable varieties. The development of the food processing industry is one of the most dynamic of any phase of agriculture today. There is a particular need for developing basic information on genetic control of enzyme systems for developing potato varieties more suitable for processing. Potentially valuable Solanum species and released varieties are not presently fully evaluated. There is need to speed up this research. To raise yields and potato quality beyond present levels requires new methods of breeding, more interspecific hybridization, and greater resistance to specific diseases. Potato diseases annually continue to cause significant losses at all levels of the industry. Basic information is needed on the nature of diseases and new methods of their control, especially biological and genetic controls. Increasingly serious are stem-end browning, after-cooking darkening, and internal black spot (all of which have their origin in the growing crop) and it is urgent that causes and cures for these disorders be found. Genetic controls for insects and nematodes are needed to supplement and if possible replace chemical control.

USDA PROGRAM

Breeding, selecting, and testing of new varieties and seedlings for horticultural characters, storing, shipping, and culinary qualities, and local adaptation are conducted cooperatively with the States at Presque Isle, Maine; Greeley, Colorado; Aberdeen, Idaho; Ames, Iowa; Baton Rouge, Louisiana; Ithaca, New York; Prosser, Washington; and Crystal City, Texas. In addition, testing of new seedlings is done at more than 20 additional locations in cooperation with State personnel.

Greenhouse crossing for production of true seed, for developing new varieties, and growing seedling tubers is done at Beltsville, Md., and to a lesser degree at Aberdeen, Baton Rouge, Prosser, and Greeley. Frost resistance is being developed in selections at Baton Rouge for winter crop production. At Aberdeen, Beltsville, and Greeley emphasis is placed on developing varieties adapted for processing. The development of insect-resistant lines is a major objective. In cooperation

with the Rockefeller Institute at Mexico City, seedlings from Beltsville are evaluated for resistance to severe late blight conditions of the Toluca Valley; significantly resistant varieties have been released. Lines resistant to wind and heat are being developed in Texas with assistance of private cooperators. Parental lines and advance seedling selections that have resistance to sloughing off and that retain their opaqueness when diced, frozen, and reconstituted are being sought, also through private cooperation, in Maine, Maryland, and New Jersey.

The world collection of Solanum stocks is maintained at Sturgeon Bay, Wis., at the Inter-Regional Potato Introduction Station. The production and study of Solanum tuberosum diploids (half the normal chromosome number) is done at Madison, Wis., along with interspecific hybridization of diploids. At Beltsville investigations of crossability among Solanum species and meiosis of species and species hybrids are being conducted.

Disease controls are sought through breeding disease-resistant varieties and basic studies on the nature of specific diseases.

Scab resistance is a major breeding objective at all locations. The evaluation of progenies, seedling selections, and species for viruses X, A, and Y is done at Beltsville. Through State cooperators seedlings from Beltsville are sent to Florida for determining corky-ring-spot resistance and to New York for resistance to golden nematode. At Beltsville work is done on the development of techniques for evaluation tests of all major diseases with particular stress on leafroll and soil-borne viruses. Studies are underway to find improved methods of disease detection.

At Greeley, Colo., lines are developed that are resistant to scab and leafroll, and at Aberdeen, Idaho and Prosser, Wash., to scab, leafroll, and verticillium wilt. Early blight and fusarium resistance tests are conducted at Aberdeen. At Baton Rouge, La., emphasis is placed on scab and late blight resistance, especially in red-skinned lines. At Presque Isle, Maine, disease evaluations are made for X, A, Y, leafroll, spindle tuber, ring rot, verticillium wilt, late and early blight, scab, and tuber necrosis. Disease control studies for late blight, scab, verticillium wilt and viruses are likewise conducted in Maine. Internal black spot is a major consideration at our New York and Washington locations. Evaluation of breeding lines for resistance to golden nematode is done cooperatively at Ithaca, N. Y. Virus S is studied at both Madison, Wis., (cooperatively with Wisconsin) and Greeley.

Research is conducted on the epidemiology of potato late blight to provide a scientific foundation for the experimental forecasts issued by the plant disease warning service. During 1962, epidemiological research was continued in three regions in cooperation with the State Agricultural Experiment Stations. Headquarters, respectively, were at Raleigh, N. C.; Ames, Iowa; and University Park, Pa. Reporting of plant diseases is through the monthly "Plant Disease Reporter" (circulation 2,200), which emphasizes such matters as new records of disease occurrence, serious outbreaks and new controls.

The Federal scientific effort devoted to research in this field totals 15.1 professional man-years. Of this total, 8.3 are devoted to breeding; 4.4 to diseases; 0.1 to variety evaluation; 1.4 to culture; 0.6 to crop introduction and evaluation; and 0.3 to program leadership.

A contract with Polish Academy of Sciences provides for the study of environmental factors affecting quality of tubers used for seed. This contract is for 5 years, 1962-1967, and involves P. L. 480 funds with a \$48,545.83 equivalent in Polish zlotys.

A contract with the Estacion de Mejora de la Patata, Vitoria, Spain, has been negotiated to develop techniques for eradicating, inactivating, or curing potato tubers from their tuber-borne viruses. Its duration is 5 years, 1963-1968, and involves P. L. 480 funds with an equivalent of \$45,959 in Spanish currency.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Breeding

1. Potato Tuber-greening. Varying potential intensities of greening of potato tubers have been observed and measured by subjective and objective methods after exposure to a combination of daylight and fluorescent light at Beltsville. Tuber samples from increase plots and yield tests grown in Maine, and from over 700 seedlings representing 9 progenies were evaluated for growing reaction. All tuber samples were exposed at 10-hours daily for 10 days, after which intensity of greening was determined by light transmittance tests. These tests made in cooperation with Agricultural Marketing Service, showed good separation of values for greening intensity. Distribution of greening values of the single-tuber seedlings of 9 progenies were typical of segregating populations when only one parent has tuber resistance to nongreening.

Of the 346 selections exposed to 100 hours of lighting the distribution of greening values was as follows: 5, none; 67, trace; 160, slight; 94, moderate; 20, intense. Most of the selections and varieties tested varied from slight to intense in greening.

2. Potato Cytogenetics. Continued emphasis has been placed upon gene transfer at the diploid level. The collection of haploids ($2n = 24$) of the common potato, Solanum tuberosum, is now in excess of 3100 and represents offspring from 58 different parents. Hybrids between the S. tuberosum "haploids" and diploid species have been obtained and studied for vigor, yield, and fertility. Striking hybrid vigor occurs among offspring of certain combinations, particularly those involving the South American cultivated diploids. Sixty F_1 hybrids from S. phureja - haploid S. tuberosum crosses were selected for tuber type and yield in the 1961 field. With the objective of testing the incidence of male and female fertility, crosses were made in 1962 among these. All 60 hybrids flowered were male and female fertile.

Thirty-four diploid species were grown at Beltsville in 1962 for cytological and crossability investigations. Chromosome pairing was normal with usually 12 bivalents at metaphase I. Seed was obtained from 62 combinations among the diploid species.

Progenies of 106 diploid hybrid combinations were grown for cytological investigations. The majority of the plants showed normal chromosome behavior. F_2 seed was obtained from sib-matings in 42 of the F_1 parents.

3. Late Blight. Over 175 advance potato selections were sent to Maine for evaluation of field resistance. Most of the selections were rated as dead (class 5) from late blight in the final August rating. One red seedling, B5091-5, was rated in class 3 in July and class 4 in August. It yielded 409 cwt. per acre in Maine in 1962, and showed field resistance to late blight, scab, verticillium wilt, and tuber-greening. A lot of 173 Mexican introductions were evaluated for field resistance in Maine; 16, which had good tuber characteristics, were saved for future use as parents.

4. Spindle Tuber. In 1962, over 300 seedlings were evaluated for resistance to spindle tuber. Only 6 clones of the 1,700 lines inoculated in 1960 remained free of virus symptoms after the first-year inoculation, 2 survived the second-year inoculation, and one seedling, B4577-66, showed only 6 percent infection after the third-year inoculation. This is the first known resistance in potatoes to spindle tuber virus.

5. Verticillium Wilt. Over 240 advance selections and 200 seedlings from 7 family lines were tested in the field for verticillium wilt resistance in cooperation with the Maine Agricultural Experiment Station. Approximately 11 percent (26) of the advance seedlings showed no symptoms in the field.

6. Leafroll. In cooperation with the Maine Agricultural Experiment Station, 241 advance selections were field-tested in 5-hill rows for leafroll resistance. Twenty showed no infection. Seedling B5031-18, a resistant sort, yielded 349 cwt. per acre and also showed high resistance to verticillium wilt.

7. Net Necrosis and Stem-end Browning. Thirty-four named and numbered varieties were tested for tuber necrosis symptoms due to seasonal infection with leafroll (net necrosis) and/or the physiological necrosis (stem-end browning). The tubers of Mohawk, Green Mountain, Fundy, and Norgleam showed 71, 89, 46, and 67 percent net necrosis, respectively, but 21 varieties and selections remained free of symptoms, including Katahdin, Penobscot, B2894-24, B3570-5, and B3692-4. Earline, LaRouge, Norgleam, Wy 1122, B2894-24, and B3570-5 had stem-end browning, tuber-symptoms varying from 3.6 to 19.3 percent, and 28 selections were symptomless or free.

8. Ring Rot. In cooperation with the Maine Agricultural Experiment Station, 265 selections were evaluated for ring rot resistance. Eleven showed no evidence of disease, and 8 showed only slight symptoms. Two resistant selections, B3478-23 and B3681-1, when grown in a replicated yield trial, produced 476 and 376 hundredweight per acre compared to 447 hundredweight for Katahdin. The specific gravity ratings for B3478-23, B3681-1, and Katahdin were 1.078, 1.067, and 1.075, respectively.

9. Golden Nematode. In cooperation with the New York Agricultural Experiment Station, 297 seedlings from 11 family lines were evaluated for resistance to golden nematode. A total of 133 (45 percent) were resistant. Seedling B5036-40, a cross between B4159-8 and Katahdin, produced 383 cwt. per acre, was of medium maturity rating, and showed good resistance to golden nematode, scab, and virus X.

10. Scab. In 1962, three hundred and fifty-three seedlings were evaluated for field resistance to common scab. Thirteen were scab-free and 64 had only a trace on their surface, whereas the Green Mountain check had from 41 to 60 percent of the tuber surface covered with type 4 pustules. Fourteen seedlings from Minnesota and 21 from U.S.D.A. were grown in nursery plots at 8 locations over the country. These showed considerable variation in type of pustule as an indicator of resistance within and between areas for various seedlings.

11. Southern Region. In cooperation with the Louisiana Agricultural Experiment Station, breeding for resistance to late blight, scab, and frost was continued. Seedling TL6937 is being tested widely for commercial possibilities. It is highly resistant to scab and late blight, has high solids, and is very good for baking and chipping. Among 70 seedlings segregating for frost resistance, several have shown high resistance combined with good horticultural characters.

12. Idaho. Producing, testing, and selecting seedlings resistant to leafroll, scab, early blight, and verticillium and fusarium wilts, continued in cooperation with the Idaho Agricultural Experiment Station. Four clones, A483-17, A576-2, A378-2, and A594-11 were outstanding in their resistance to verticillium wilt. In the scab test exceptional resistance was observed in seedling B3457-2. Five seedlings, B3948-5, B3983-2, A465-8, A495-6, and A465-11 from a field test of 44, were exceptionally high in their resistance to late blight. In the 1962 fusarium wilt test, 31 clones were exposed to "eumartii wilt." Early Gem, Russet Burbank, A576-2, A378-2, and A483-17 were the five selections that showed the most resistance in their foliage. All the lines, however, had a relatively high percentage of tuber infection.

13. Colorado. In cooperation with the Agricultural Experiment Stations of Colorado and Wyoming an isolation plot was established at the Cheyenne Horticultural Field Station to increase disease-free seedlings from the Greeley Colorado program. A total of 45,000 first-year seedlings from 130 family lines was grown in 1962. Over 1500 selections were made for replanting and evaluation in 1963. Advance selections were tested for resistance to scab and leafroll. Tests were set up to evaluate seedling lines for resistance to verticillium wilt and viruses X and Y.

14. Washington. In cooperation with the Washington Agricultural Experiment Station, breeding and testing for resistance to verticillium wilt, common scab, late blight, and certain viruses continued. About 35,000 new seedlings were grown in the field in 1962. Eleven seedlings and 10 varieties exposed to natural leafroll in 1961 were read for symptoms in 1962. Seedlings B4102 and Ia3769 showed only 10 percent infection compared to 100 percent for ND3815-1R (Viking). Five selections were saved from 226 tested for verticillium wilt. B4987-6, B5011-31, and B5063-3 showed no vine symptoms in the field and were satisfactory when tested for total solids. Chipping tests on 36 selections after storage at 40° C. for 3 months were made in December. Eleven produced high quality chips. B3620-1, one of the best for quality, is also highly resistant to verticillium wilt.

14. Texas. About 10,000 seedlings from 30 crosses were grown in single-hill units in Texas and 150 seedlings were grown in 5-hill plots for observation at 6 locations, plus a replicated yield test at 3 locations. Ona and Catoosa, 2 recent releases, compared very well in yields to Red Pontiac when grown at Crystal City. Thirty-four new selections were made and sent to Colorado for increase.

B. Diseases

1. Spindle Tuber Virus. In further work on the transmission of the potato spindle tuber virus to tomato, the virus was transmitted from 8 different potato clones to Rutgers tomato. Tissue from tomato was then used to inoculate a total of 237 potato plants of 3 varieties by both grafting and sap inoculation. An average of 66% of the potatoes inoculated by means of sap later developed symptoms of the spindle tuber disease. One hundred percent of those inoculated by grafting became infected. These data support the original finding that tomato is a host of the spindle tuber virus.

In a test with 32 tubers unknown as to variety or disease content, spindle tuber was correctly diagnosed in 14 of the 16 diseased plants. In a later test all 16 of the diseased plants were detected. A further test with 120 different clones grown on Aroostook Farm in Maine resulted in the diagnosis of spindle tuber in approximately 77% of these plants tested. These findings demonstrate that tomato can be used as an indicator plant for the spindle tuber virus.

In studies with other tomato varieties none have been found to be superior to the Rutgers variety as indicators for the spindle tuber virus. Studies on the host range (17 species) of the potato spindle tuber virus using tomato as an indicator plant have shown 6 solanaceous species to be symptomless hosts of this virus. These are the first symptomless hosts reported for the spindle tuber virus. Other workers have reported 10 species of Solanum to be susceptible.

Studies on the purification, electron microscopy, and serology of the spindle tuber virus are now underway. Methods for extraction and purification of the virus are in the intermediate stage of development with studies on concentration of the virus receiving the most attention.

2. Solanum Species Evaluation. Approximately 200 clones involving 42 Solanum species were evaluated for resistance to viruses X, Y, and leafroll. About 100 of the clones belonged to the species andigena. Sixty-one clones, of which 49 were of the species andigena, were resistant to virus X. Only 6 clones of the 200 tested were resistant to virus Y when inoculated by means of viruliferous aphids. About 18 clones were resistant to the leafroll virus when inoculated by means of aphids. Apparently resistant clones will be retested in 1963.

3. Breeding Selections Evaluation. Approximately 400 advanced breeding selections were tested for resistance to viruses X, Y, and A. About 160 appeared to be resistant to mechanical inoculation with virus X; 86 were resistant to virus Y when exposed to viruliferous aphids in the field; 187 were resistant to virus A when exposed to viruliferous aphids or when grafted with the virus.

4. Late Blight. About 250 advanced breeding selections were tested for resistance to the common and the specialized races of late blight fungus in the greenhouse at Beltsville, Maryland, and for resistance to the common race in the field at Presque Isle, Maine. Over 100 were resistant to the common race in the greenhouse; 86 carried the R_1 gene, 69 the R_4 gene, 47 the R_3 gene, and 3 the R_2 gene. Forty-five selections showed two major genes in combination and 21 selections had 3 major genes in combination. In the field most selections which had any of the major genes remained free of blight until about the 20th of August when new races of blight made their appearance. One hundred and thirteen of 283 selections tested in the field plot remained free of blight until August 20. Twenty-seven selections remained free of blight until the end of the season.

Field resistant selections from material originally sent to Mexico for preliminary testing were also tested for blight resistance in the field. Of the 116 tested, 13 were found to be susceptible to the common race of blight in the field prior to August 20; 30 remained resistant to blight until that date; 73 remained free of blight until the end of the season.

5. Late blight of potato and tomato. In the north central region investigations on conditions responsible for outbreaks of potato late blight (*Phytophthora infestans*) were continued. Development of late blight from inoculated seed pieces was watched in unsprayed "late blight gardens" at Ames, Boone, and Clear Lake, Iowa. Fewer sprouts were produced by inoculated than by uninoculated Cobbler and Red Pontiac seed pieces at Ames and Red Pontiac seed pieces at Boone; the reduction in emergence was especially severe in the heavier black mineral soil at Boone, where only 57 percent of inoculated as compared with 98 percent of uninoculated seed pieces produced sprouts. Some primary blight lesions appeared on sprouts at Ames and Boone but disappeared without secondary spread after the middle of June. Meteorological data indicated that during the period of rapid lesion growth temperature and moisture were unfavorable for sporulation and reinfection. With the advent of more favorable weather there were no young lesions to resume development. The foliage was relatively open and the small plants afforded the fungus relatively little protection from sunshine and air circulation during a 14-day period with temperature maxima over 80° F. No blight symptoms were observed on emerging sprouts or mature plants at Clear Lake although temperature and moisture conditions there would have favored aerial development; perhaps a late planting date and rapid emergence in warm soil prevented the fungus from invading the growing sprouts.

During June, July, and August dew records taken visually and with three different dew recorders were compared with each other and with relative humidity data recorded by a hygrothermograph in the same plot. For the visual dew observations the leaves of a number of potato plants were closely examined with the aid of a flashlight and a hand lens. Dew "burn-off" was recorded at the time the upper leaves dried off. Some of the lower leaves on the older plants were wet all day and dried off only if the relative humidity was low or a breeze was blowing. The time of "burn-off" from the upper leaves most closely approximated that recorded by dew recorders. The field studies revealed that all instruments were useful in identifying dew periods; that the lamb-gut sensor type was slightly more sensitive than other recorders in identifying time and duration of dew deposition; that 90 percent relative humidity periods were generally longer than dew periods recorded by any of the dew recording instruments; that dew was usually recorded by the lamb-gut recorder 18 minutes after dew appeared on the foliage; that dew appeared on the foliage about 30 minutes before the relative humidity reached 90 percent in the lowered hygrothermograph shelter; that dew generally "burned-off" the foliage 5 minutes after the relative humidity dropped below 90 percent; and that dew "burned-off" the foliage 57 minutes earlier than from the Taylor glass plate dew recorder.

The United States Weather Bureau again furnished records of the number of consecutive hours of temperature-dew point spread of 3° at 90 percent relative humidity for ten first-order weather stations for the period June 18 - September 15. In addition, the Bureau provided weekly synoptic weather reports translated into possible indications of late blight conditions for the region. The information was most useful in augmenting data for the weekly late blight predictions. The Bureau will continue to supply the late blight regional weather data.

Experimental blight forecasts were issued from 23 weather-blight forecast stations in the North Central States. Reports indicated that the forecasts were accurate in most States; information from others is lacking or insufficient to judge accuracy.

In the southeastern region late blight forecasts were made for commercial potato-growing areas around Charleston, South Carolina, and Aurora (Eastern Shore) North Carolina. In both locations weather from the beginning of April until the end of May did not favor the development of late blight. Between the end of May and the time of harvest conditions were very favorable for sporulation and spread, but apparently the earlier unfavorable period had prevented establishment of the fungus since the disease was not reported except in some irrigated fields in North Carolina. Its presence in the irrigated fields, where it was found on June 8, showed that the fungus could become established in such fields and persist undetected until weather favored secondary

spread. All original infection centers appeared in rows adjacent to main water carrying ditches where the soil was continuously moist. 1962 was the third consecutive year that late blight was not reported on tomato plants in the Eastern Shore of South Carolina.

In the northeastern region research on late blight forecast methods was continued. In a "late blight garden" at Penn State University only 6 plants emerged from 118 inoculated Katahdin seed potato tubers incubated at 70° to 60° F for 12 hours on each of 8 days before being planted in dry soil. The fungus was found on a sprout that failed to emerge, but no blight developed on the 6 plants that came up. The season was dry and no blight occurred elsewhere in the vicinity.

Field blight stations were established in four commercial potato-growing areas in Pennsylvania, in York, Lehigh, Potter, and Erie Counties, for comparison of forecast methods. Methods based on temperature and 90 percent relative humidity records and on temperature and rainfall data were equally satisfactory for predicting occurrence of late blight under the varying conditions of these commercial areas. Certain restrictions should be noted: for the temperature - 90 percent relative humidity method, an infection period should be disallowed if the maximum temperature on the following day exceeds 85° F; for the temperature - rainfall method, blight-favorable periods (especially minimal ones) early in the season when the plants are small should be disallowed.

Regional late blight forecasts for the northeastern region were discontinued in 1962, in accordance with the goal of the forecast research program, understood as the development and verification of forecast procedures for eventual utilization by other agencies. The regional pathologist initiated programs leading to assumption of local responsibility for the forecasts as early as 1960 in some parts of the region. In the various areas different methods of handling forecasts have been adopted, notably in Maine and New Brunswick where a cooperative program was set up, and in New Jersey where a newly appointed Advisory Agricultural Meteorologist took over the forecasts.

6. Screening for Viruses. One hundred and forty-four potato introductions were indexed at Glenn Dale, Md., for viruses and of these 72 were found to be infected with one or more serious virus diseases while 54 were released as virus free or contained only virus S. Eighteen introductions were destroyed as hazardous.

C. Variety Evaluation

1. New Releases

Penobscot, a new white variety leafroll and field immune to mild mosaic, is consistently high in dry matter, yields satisfactorily, and has shown good chipping and French frying qualities at harvest time and at intervals after storage and reconditioning. (joint with Maine Agricultural Experiment Station) Shoshoni is a high-yielding, round russet variety with good processing characteristics for dehydrated products and resistance to scab and verticillium wilt. (joint with Idaho Agricultural Experiment Station) Reliance, a medium-maturing, white variety, has shown moderate resistance to late blight, common scab, russet scab, silver scurf, aster yellows, and leafroll, and is immune from latent mosaic. (joint with Minnesota and North Dakota Agricultural Experiment Stations) Reliance is primarily a fresh-market variety but acceptable chips have been made from it immediately following harvest.

2. Outstanding Seedlings. Several outstanding seedlings were observed in 1962. B5063-3, a high-yielding red selection, was selected independently by workers in Maine, North Dakota, Colorado, and Washington. It has shown resistance to tuber-greening, silver scurf, scab, verticillium wilt, leafroll, and virus Y. It had excellent solids content at the four locations and chips well following 40° F. storage. It produced 354 cwt. of U. S. No. 1 tubers per acre in Maine. B5141-6 is a fertile, medium-maturing selection with scab resistance that produced 321 cwt. per acre. It is exceptionally high in total solids and does not accumulate reducing sugars readily when placed in storage for several months. B4523-8, a nongreening type, produced 472 cwt. per acre of U. S. No. 1 tubers compared to 437 cwt. for Kennebec. It is also resistant to scab, late blight, virus A and the golden nematode. B4557-2 yielded 517 cwt. per acre compared to 440 cwt. for Katahdin. It is very resistant to late blight, scab, and the golden nematode. The qualities of these last two are under study.

3. Potato Introductions. In cooperation with Plant Introduction Investigations of the New Crops Research Branch 645 new stocks were received in 1962, from 12 countries (Argentina, Bolivia, Canada, Chile, Colombia, Ecuador, England, West Germany, Guatemala, Mexico, Netherlands, Peru). Nearly two-thirds of these introductions were of the species S. andigena from the collection of Dr. H. J. Toxopeus, Wageningen, Netherlands. This species continues to be an unusually promising source of germ-plasm for improvement of the commercial potato.

A Solanum expedition to Mexico and South America is currently underway, sponsored by the National Science Foundation. The IR-1 project will receive seeds or tubers of all Solanums collected by this expedition.

Shipments of 419 seed lots and 2033 tuber lots were made during the past year to 22 States and 20 foreign countries.

D. Culture

1. Specific Gravity Readings. All seedlings and standard check varieties grown in the early-medium-, and late-variety yield tests and 358 advance seedlings grown in 50-hill plots were compared for yielding ability, U. S. No. 1 grade percentages, specific gravity, and chipping quality. The specific gravity readings were generally low this year but seedlings B5063-3 and B5141-6 had readings of 1.084 and 1.095 which were exceptionally high. Both these selections are suitable for chipping.

2. Cooperative Research. Evaluation tests in cooperation with Campbell Soup Company have uncovered seedlings that do not slough off or become translucent after they have been diced, frozen, and then reconstituted. Crosses are being made with seedlings that have these characters.

3. Environmental Studies. A P.L. 480 project in Poland was initiated in 1962 to study the influence of low and high temperature and different kinds of soils on parent plants and on the yield and development of the succeeding generation of potatoes. No adequate research results have yet been obtained on this project.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Breeding

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Variety Evaluation

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NEMATODE CONTROL
Crops Research Division, ARS

Problem. Plant-parasitic nematodes occur in all soils used for growing of crop plants and attack all kinds of plants grown for food, forage, fiber, feed, or ornamental purposes. It has been long known that severity of attack by certain fungi is greatly increased if nematodes are present; and nematodes have been known to be the vectors of several plant viruses. There is a need for improvements in the methods of controlling nematodes by crop rotations, cultural practices, chemicals and biological methods on potatoes.

USDA PROGRAM

The Federal scientific effort devoted to basic and applied research on nematodes is 21.5 professional man-years, of which 0.3 is devoted to research at Madison, Wisconsin. There is a P.L. 480 contract at LaMolina, Peru, for research on the golden nematode of potatoes.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Investigations of the golden nematode of potatoes (*Heterodera rostochiensis*) at LaMolina, Peru, under P.L. 480 Project No. S8-CR-5 have developed information on the distribution of this nematode in Peru and on its temperature relationships. The nematode is not found in Peru below an altitude of 6,000 feet, even though potatoes have been grown for many centuries in the coastal plain region of the country. It has also been found by controlled experiments in the greenhouse that the optimum soil temperature for development of this nematode is between 60° to 70° F, with no development above about 75°. The relationship between the distribution and soil temperature is being explored.

INSECT CONTROL
Entomology Research Div., ARS

Problem. The profitable production of high-quality potatoes demanded by the consumer necessitates the control of injurious insects. Available control methods involve the use of insecticides, some of which are not adequately effective because of resistance of the insects to them. Certain insecticides may leave undesirable residues on or in potatoes. There is, therefore, continuing need for research to develop safe, effective, and economical methods of control. The overall problem is complicated in that many of the virus diseases of potatoes are transmitted by small populations of insects that otherwise would be of little importance. Sometimes it is not known which insects are responsible. It is important to learn the identity, distribution, and ecology of the vectors of diseases of potatoes in order to make an intelligent approach to the development of methods for preventing insect transmission of the diseases. There is an especial need for research on the ecology and biological control of potato insects; and for research on the evaluation of potato varieties for insect resistance. Growing concern over problems associated with insecticides, which may include adverse effects from residues in the soil, contamination of non-target areas and interference with the work of natural enemies of insect and mite pests, makes it imperative that an increasingly strong research effort be directed to the development of non-chemical methods of insect control or of ways of using chemicals that will avoid objectionable side-chain effects.

USDA PROGRAM

A continuing program involving basic studies on the biology, ecology and pathology of insects that attack potatoes in the field or transmit virus diseases, as well as applied research on their control is conducted by the Department at Yakima, Wash.; Orono, Me.; Beltsville, Md.; and Charleston, S.C., in cooperation with the respective State Experiment Stations, the Washington Department of Agriculture, the Washington State Potato Commission and industry.

The Federal scientific effort devoted to research in this area totals 6.3 professional man-years. Of this number 1.9 is devoted to basic biology and physiology; 2.1 to insecticidal and cultural control; 1.0 to insecticide residue determinations; 0.3 to biological control; 0.2 to insect attractants; 0.1 to varietal evaluation for insect resistance; 0.4 to insect vectors of diseases; and 0.3 to program leadership.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Basic Biology and Physiology

1. Wireworms. These insects appear likely to become the most destructive pests of vegetables and other crops in the million-acre Columbia Basin Irrigation District of Washington during its rapid transformation from semi-desert to irrigated farmland. Since 1950, the indigenous Great Basin wireworm (Ctenicera pruinia) has decreased in abundance because it thrives on bunch grass in non-irrigated grain lands and is not adapted to irrigation conditions. Although this wireworm is destructive to potato seed pieces and developing tubers during the first year or so after a field is first irrigated, research has shown that few can survive more than three years of irrigation farming. The sugar beet wireworm (Limonius californicus), Pacific Coast wireworm (L. californicus), and Columbia Basin wireworm (L. subauratus) have been present in older irrigation districts of Washington since the early twenties and are likely to replace the Great Basin wireworm in the newly irrigated areas where they can be very destructive. In recent years, the Pacific Coast wireworm has moved into the Columbia Basin, where the light, sandy soil is especially favorable to it. Losses to potato growers by this species, first reported in 1959, have increased in severity and become more widespread each year. The Columbia Basin wireworm is now highly resistant to aldrin, although this material has never given consistent control at registered rates. In 1962, a three-pound-per-acre application failed to prevent a total loss of potatoes in some fields. In one case where the crop was quarantined because of aldrin-dieldrin residue in the tubers above the legal tolerance, a gas chromatographic analysis showed excess insecticide residues in the wireworm damaged tubers.

In South Carolina all attempts to get laboratory-reared adults of the southern potato wireworm to deposit fertile eggs in the laboratory have failed. Wild adults caught in black-light traps lay fertile eggs freely. Most of the eggs are laid at night and it is at night that the adults come to light traps, mostly before 8:30 p.m. The recent discovery of a method of sexing the insect in the pupal stage has made it possible for the first time to isolate and pair virgin male and female adults without causing physical damage. However, all attempts to observe attraction between the sexes in the laboratory have failed. The damage to crops caused by this wireworm continued to spread in the South. Spread of this insect northward appears to be limited by its inability to survive for long in subfreezing temperatures. Subnormal temperatures at Charleston in December 1962, for example, killed about 67% of the wireworms in untreated plots under observation.

2. Foxglove Aphid. In Maine, results of intensive studies over a period of 5 years on the biology of the foxglove aphid have been assembled and prepared for publication as a Technical Bulletin of the Department. Prior to 1956 when the primary host of this aphid in Maine was discovered to be

hawkweed, the source of the large numbers found on potatoes each spring was a mystery. This insect is one of the 4 aphids that attack potatoes in the Northeastern States and cause injury by their feeding punctures, toxic secretions, and by spreading virus diseases. These and less intensive studies over the past 20 years show that in New Jersey and southward the foxglove aphid continues to feed on available host plants and reproduce parthenogenetically, giving birth to living young throughout the year. Some are wingless, whereas others are winged and fly to other hosts. However, north of New Jersey a sexual generation of males and females develop on hawkweed in October which produces eggs that are able to survive the severe winters. In Maine, the eggs hatch in early May and produce winged asexual females that mature from early June to late July and migrate to the potato fields.

3. Six-Spotted Leafhopper. Field cage studies verified earlier suspicions that this insect overwinters to some extent in the egg stage in barley plants in eastern Washington and that the large populations of the leafhopper found there during the summer are not dependent upon spring migrations from the South. The common weed, horsetail (Conyza canadensis), was an abundant overwintering reservoir of aster yellows during the winter of 1961-62 and apparently was responsible for more than usual abundance of aster yellows on carrots and other susceptible crops.

4. Seed-Corn Maggot. Unusually large numbers of puparia of this insect were found in the soil of several Columbia Basin, Washington, fields screened during the early spring of 1963. Later, many fields were planted with freshly cut potato seed pieces during the rainy week of April 21, and a few fields required replanting because of maggot injury and associated rotting of the seed. In fields where seed lots had apparently suberized somewhat (cut surfaces healed) before planting, the maggots had entered through wounds made during the planting process by the tic-type planters used. Heavy maggot populations developed frequently in potato seed pieces in fields where heavy green manure crops had recently been plowed down.

B. Insecticidal Control

1. Green Peach Aphid. In Washington, experiments started in 1962 on the control of the green peach aphid and completed in 1963 with the evaluation of chronic (tuber perpetuated) leaf roll showed a marked decrease in the number of plants that became infected with this aphid-borne disease as the number of applications of the aphicides increased from 1 to 4. The percent of chronic leaf roll was reduced from 42 to 7 by the control of the aphid with endosulfan, 48 to 9 with Meta-systox, and 24 to 14 with endrin. Previous study at Yakima, Wash., showed that the effectiveness of band applications of 2 pounds of Di-syston or phorate per acre in granules to light soil, or 3 pounds per acre to heavier soil in the planting furrow in March or April did not last until the main summer flight of aphids. Tests in 1962 showed that the period of good protection against establishment of aphid colonies could be prolonged by delaying the soil band application

until about May 15 when the insecticide can be conveniently mixed with part of the fertilizer usually sidedressed to the crop at that time. Residues of Di-syston were below the tolerance where treatments were made 90 days prior to harvest.

2. Aphids. In Maine, low aphid populations at Presque Isle made it difficult to evaluate control methods; however, 1 pound of Di-syston per acre in the planting furrow continued to be effective and was superior to 1 pound of Menazon or 2 of phorate. Three weekly applications of insecticide to the foliage, starting in mid-June, provided generally less effective all-season control of the aphids than did applications made whenever aphids could be found on 50% of the plants by examining only 3 leaves per plant, one each from the top, middle, and bottom of the plant. Using the latter criteria, only 1 application of Meta-systox at $3/4$ lb. per acre was required, as compared with 2 applications for parathion, endothion, or endrin at $1/4$ lb. per acre. Aphids were not sufficiently abundant to cause feeding damage that would be reflected as reduced yield of tubers.

3. Southern Potato Wireworm. In South Carolina, exploratory tests with 34 new materials revealed 4 worthy of further tests, adding to the list of experimental materials having promise for controlling this wireworm. In the meantime, the recommended parathion and diazinon treatments continued to give good protection of potatoes under most conditions. However, there was some evidence of resistance on the part of the wireworm to parathion. Of the new materials that show promise phorate could be recommended were it not for the fact that residues may be deposited in the tubers under some conditions and there is no established tolerance. A similar material, Di-syston, has a tolerance in potato but appears to be inferior against this particular insect. The other promising materials are strictly experimental. Information on the biology of this insect and how to control it on potatoes has been prepared for release to growers as a USDA leaflet.

C. Insecticide Residue Determinations

1. Dieldrin Residues in Potatoes. As a result of seizures by the Food and Drug Administration in the Pacific Northwest of potatoes containing aldrin-dieldrin residues in excess of the tolerance of 0.1 p.p.m., analyses were made by the chemists at Yakima, Wash., by gas chromatography of a large number of samples of potatoes and soils in which they were grown. The results of these analyses indicated in general that the application of 5 lb. of aldrin per acre as a granulated formulation broadcast and cultivated into the soil under some conditions may result in aldrin-dieldrin residues in the potato in excess of tolerance. Similar applications of 6 lb. of dieldrin per acre did not result in excess residues. In some instances grower applications of 2 to 3 lb. of aldrin per acre applied as a sidedressing resulted in residues in excess of the tolerance. At Beltsville, Md., excess residues also were found in potatoes grown in Maine in soil treated before planting with 3 pounds of aldrin per acre. As a result of these studies USDA has ceased to register or recommend the

use of aldrin in the soil for insect control on potatoes. Consequently, stocks of Farmers' Bulletin No. 2168 "Controlling Potato Insects," which contained recommendations for the use of aldrin in the soil for control of potato insects, were destroyed and a revision printed without such recommendations.

2. Di-syston Residues in Potatoes. Potatoes were treated with 2.0, 2.5, and 3.0 pounds of actual Di-syston per acre as a sidedressing. Samples taken 78 to 96 days after treatment contained from 0.04 p.p.m. to 0.24 p.p.m. of Di-syston, which is well below the tolerance.

3. No Dimethoate Residues from Foliar Treatment of Potatoes. At Yakima, Wash., no measurable dimethoate residues were found in potatoes that had received 5 foliar sprays at 2-week intervals using 1/4 lb. dimethoate per acre per application.

D. Biological Control

1. Aphids. In Maine a long-term survey study was continued on the insect parasites, predators, and fungus diseases of aphids affecting potatoes. Quantitative records of the abundance of each type of control agent in plots and fields of potatoes at Presque Isle and to some extent elsewhere in Northeastern Maine were accumulated and the parasites and fungi were identified, the latter by the California Agricultural Experiment Station. While neither the parasites nor the predators appeared to exert a substantial effect upon aphid population trends on potatoes, fungus disease had a mid- and late-summer effect with peak abundance of the potato aphid substantially below the expected abundance in the absence of fungus action. In 1962 the predominant species of fungus was Entomophthora ignobilis. The most important insect predators were the lady beetles, Coccinella transversoguttata and Hippodamia 13-punctata tibialis. The most common species of parasites in 1961 were Aphidius nigripes and Praon spp. About 36% of the primary parasites were infested with hyperparasites in 1961. One shipment of a parasite, Aphidius avenae, from France was liberated in a field of aphid-infested potatoes in Maine but the evidence thus far indicates the parasite has not become established.

E. Insect Vectors of Diseases

1. Aphids. Tuber samples from plots sprayed in 1961 were planted, grown, and observed in 1962 at Presque Isle, Me., for symptoms of leaf roll to determine what effect the spray treatments had upon seasonal spread of this aphid-borne virus disease. Endosulfan, endrin, and Menazon applied for aphid control appeared to be effective in preventing spread of leaf roll on Katahdin potatoes. There was virtually no spread of the disease in Katahdin, Green Mountain, or Chippewa potatoes where an application of Di-syston at 1 pound per acre was made in the planting furrow, whether the abundance of infected tubers planted was 1% or 4% of the stand. Katahdin has some resistance to leaf roll under field conditions; and Green Mountains

and Chippewas are rather susceptible to the disease. Although little spread occurred in untreated potatoes, the amount was correlated with the abundance of infector plants and the aphid-days of infestation to which the plants were subjected. Virtually all of the spread was by aphids that developed within the plots; very little if any was brought into the plots by winged, incoming aphids. Preliminary greenhouse readings of leaf roll from samples of potato tubers at Presque Isle indicate that no protection from infection by viruliferous green peach aphids was afforded caged plants of the Kennebec variety in 1962 when they were sprayed with water mixtures of compounds that possessed antifeeding properties or repellency for the green peach aphid. However, there may have been some reduction in infection when the plants were sprayed with mixtures containing 2,000 p.p.m. of chlorocholine chloride, Sarcocyl, or of Aerosol OT before being infested for 24 hours with the viruliferous green peach aphids.

2. Six-Spotted Leafhoppers. Aster yellows is a cause of an internal discoloration of potatoes in the West. Results of an experiment in Washington verified suspicions formed several years ago that an internal grade defect resembling the net necrosis caused by leaf roll virus, can result from an infection of the California strain of aster yellows. Although workers in New York, Pennsylvania, and Colorado have reported aster yellows responsible for internal discoloration of potato tubers, this is the first record for the Far West. In this experiment, a number of Montana-grown certified seed potatoes were cut and planted in clay pots in April and placed in the isolation greenhouse. Cages were placed over each plant and on May 1 viruliferous six-spotted leafhoppers (Macrostoteles divinus Uhl.) were removed from a diseased Erigeron canadensis plant and placed in each cage. The leafhoppers were allowed to feed for three weeks and then killed by fumigation. Internal discoloration resembling that caused by leaf roll was found at the stem ends of the new-crop tubers when examined August 31.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Basic Biology and Physiology

- Wallis, R. L. 1962. Spring migration of the six-spotted leafhopper in the Western Great Plains. Jour. Econ. Ent. 55: 871-4.
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Insecticide Residue Determinations

- Landis, B. J. 1963. "What is the wireworm situation in Washington?" Second Annual Washington Potato and Vegetable Conference Proceedings. Washington State University, pp. 50-2.
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Insect Vectors of Diseases

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POTATO PLANTING AND FERTILIZING EQUIPMENT
Agricultural Engineering Research Division, ARS

Problem. New types of fertilizers and the increasing use of irrigation in the production of potatoes has made it desirable that equipment be developed to plant at the optimum depth and distances and at the same time apply fertilizer in the optimum amount depending upon the analysis and at the most satisfactory position with respect to position of the seed piece.

USDA PROGRAM

The Department has a continuing long-term program of applied engineering research on planting methods and means of applying fertilizer on various crops. The Federal scientific effort devoted to research in this area totals 9.9 professional man-years; of this total 0.4 are devoted to potato planting and fertilizing equipment.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

In irrigated potatoes in Arizona, heavy fertilizer (1000# 16-48/A) showed placement of continuous bands at four inches on each side, two inches below were superior to closer and wider placement. This is definitely different from the accepted placement on dry land potato culture of two inches on each side and slightly below seed piece.

During two seasons of field experiments with potatoes in Western Washington, with each nutrient of the three primary fertilizer elements used separately and in combination in both band and broadcast patterns, banding in all combinations was conclusively superior to broadcasting. However, when heavy rate applications showed salt injury to the stand, broadcasting part of the nitrogen with the remainder of the fertilizer in bands gave the best results.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Mortensen, W. P., Baker, A. S., and Hulburt, W. C. August, 1962. Effects of Placement of Nitrogen, Phosphorus, and Potassium Fertilizers on Yields and Foliar Composition of Potatoes. Presented at American Society of Agronomy Meeting, Cornell University, Ithaca, New York (Soil Sci. Div.).

CROP HARVESTING AND HANDLING OPERATIONS AND EQUIPMENT
Agricultural Engineering Research Division, ARS

Problem. This area is concerned with the development of equipment and methods for efficiently harvesting and farm handling crops, with emphasis on the preservation of inherent qualities during these processes. The cost of harvesting and farm handling of most crops is the major expense of production, often amounting to over half of the total returns to the producer from the sale of the product. In addition, supply and adequacy of manpower for these operations are becoming progressively less satisfactory.

USDA PROGRAM

The Department has a continuing long-term program involving agricultural engineers engaged in both basic and applied research on the engineering phases of crop harvesting and handling. Potato harvesting research, cooperative with the Red River Valley Potato Growers' Association, is being conducted at East Grand Forks, Minnesota. The Federal engineering effort devoted to research in this area totals 30.5 professional man-years, of which 2.0 is on potatoes.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Multi-Row Harvesting of Potatoes. A two-row digger with a long-reach windrowing attachment was improved by increasing wheel and tire size. Several other units were made up by growers and manufacturers. These units were used in harvesting a considerable acreage and made possible the harvesting of six rows at one time which resulted in increased harvester capacity while at the same time reducing the total machine cost and wear.

Spillout Losses and Roller Shares in Potato Harvesting. Follow-up studies again showed that using paired roller shares in open front type two-row diggers eliminated center spillout and vine clogging. Several commercial manufacturers are now making roller shares available for this type of harvesting equipment.

Mechanical Injury of Potatoes. Bruising continues to be one of the major problems in storing and handling potatoes. Investigation of the relation of susceptibility of potatoes to bruising and shear strength of potato tissue did not show any correlation. Apron links of 2 1/2-inch pitch with molded-on rubber cushioning in the form of rubber flats cantilevered rearward from the link were designed and made up. Preliminary tests indicate that these links result in good cushioning and therefore, less bruising, have a high capacity for soil separation, and have potential for sizing.

Engineering Cost Study of Harvesting and Handling Potatoes. In cooperation with the Economic Research Service an engineering cost study on harvesting and handling potatoes has been initiated. This study will include tables and charts that growers may consult and determine the costs of their operation

based on capital investment, capacity of machines, acreage, and yield. From this study a farmer may determine his best combinations of equipment and methods of operations for the acreage under cultivation. The data covers potato farms from 95 to 700 acres and a publication is now being prepared for early release.

Minimum Tillage for Potatoes. The study of deep tillage in the spring, deep tillage in the fall, fall plowing, and no tillage (planting directly in the wheat stubble) was repeated for the second year. Although planting conditions were different (6.52 inches of rainfall in May 1962 as compared to .81 inches in May 1961) results again showed that the amount of clods and yields per acre were not effected by pre-plant tillage practices. In fact, in both years potatoes planted directly in wheat stubble resulted in the greatest yields.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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Soil Management for Potatoes on Fargo-Bearden Soils. Minnesota Farm and Home Science.

II NUTRITION, CONSUMER AND INDUSTRIAL USE RESEARCH

UTILIZATION RESEARCH AND DEVELOPMENT

Western Utilization Research and Development Div., ARS

Problem. The potato industry, faced with a continuing decline in the consumption of fresh potatoes, is becoming more and more dependent upon the development of new and improved processed products to maintain markets and to avoid recurring economic disasters. Crop perishability, supply fluctuations, and the inelasticity of demand, result in wide swings in price with even slight surpluses. In producing areas having a substantial processing industry, depressive lows are moderated by advance contracting by processors prior to harvest. However, in many important potato growing areas processing has not yet developed, and vulnerability not only still exists, but is exaggerated by the growing competition of processed potato and other competing food products. A continuing improvement in processed potato products is clearly required if processing is to expand fast enough to offset the progressive decline in use of fresh potatoes.

To improve the quality of processed potatoes, ways must be found to eliminate the stale, "earthy," rancid, "green," and "warmed-over" flavors that are sometimes encountered in potato products, including dehydrated mashed potatoes, dehydrated diced potatoes, frozen French fries, frozen patties, and potato chips. Equally important, methods must be devised to retain the desirable natural flavor of the freshly cooked potato in the processed product. Recently developed research methods offer an opportunity to isolate and identify the chemicals responsible for the natural flavors and the off-flavors, to develop rapid and sensitive analytical methods for their measurement, and to determine the raw material factors controlling formation of the various desirable and undesirable constituents in the fresh potato. Further improvement in the texture of potato products is also needed. Fundamental histological and chemical investigations could be used to determine the causes of differences in the texture of potatoes, as a basis for developing improved processing methods. Enzymes play a great part in the entire compositional pattern of the potato, not only the constituents responsible for flavor, off-flavor, color, and texture, but also those responsible for disorders such as "black spot." Black spot causes severe losses both to those who market potatoes fresh, and to those who process potatoes, because trimming costs are sharply increased and yields reduced. Increased knowledge of enzymes is needed as a basis for solution of the black spot and similar problems, to increase use of potatoes by reducing costs, and to improve quality of both fresh and processed potatoes.

USDA PROGRAM

In the Western Utilization Research and Development Division, basic and applied research on potato products is conducted at the Division headquarters at Albany, California, and by grant funds under P.L. 480 in

England and Sweden. The chemistry of potato flavor and the compounds involved in deterioration of potato products are studied to provide a basis for new and improved potato processes and products. Histochemical studies are conducted to elucidate factors involved in the texture of potato products. Basic investigations on the enzyme systems involved in potato product discoloration and the role of sulfur dioxide in preventing non-enzymatic browning are in progress.

The Federal program of research in this area totals 9.7 professional man-years. Of this number, 5.5 are assigned to chemical composition related to flavor, color, and texture of potato products and 4.2 to technological and engineering research on new products and processing methods. In addition, the Division sponsors two research grants under P.L. 480 on basic studies.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition Related to Flavor, Color, and Texture of Potato Products

1. Flavor Components. The chemistry of volatile components connected with food flavor has advanced spectacularly in recent years by application of gas-liquid chromatography. Dual columns with dual-flame ionization detectors and programmed temperature control achieve remarkable sensitivity. The combination of gas-liquid chromatography with time-of-flight mass spectrometer separates and identifies substances in fractions of a part per million including materials whose separate existences are transitory. Research in this area has been supported in part by the Instant Potato Granule Manufacturers Association, who have supplied the salary of a scientist assigned to studies on volatile constituents of potatoes. (The position is currently vacant.)

Refinements in separation and detection of volatile components do not, however, eliminate need for large-scale extractions so as to recover workable amounts of substances that exist in the parts per million concentration range of the original food. Identifications of some classes of flavor constituents continue to defy existing gas-liquid chromatography and other ultramicro methods. A solvent extraction facility is under construction and nearing completion at Albany, California, that will allow for extraction with necessary low flash point solvents on a sufficiently large scale to make progress on identifications not heretofore possible.

Studies have continued on the volatile constituents of potatoes that are involved in flavor. When cooked potatoes are held in a wet mashed state a very rapid oxidation of lipids occurs. The volatile compounds produced in this oxidation seem to be largely lost in dehydration. However, non-volatile peroxides remain and may trigger subsequent autoxidation in dehydrated products. Small concentrations of antioxidants and chelating agents during the mashing operation prevent subsequent autoxidation. This laboratory work indicates that potato granules may be more stable if antioxidants

or chelating agents are added directly after the cooking step. Preliminary studies on storage of commercially prepared potato granules containing five parts per million of the antioxidant BHT indicate that a close correlation exists between the amount of hexanal formed and the off-flavor development.

In the gas-liquid chromatography of volatiles above potatoes and potato products a number of aldehydes were separated and identified. As a step toward demonstrating the contribution of each substance to the overall flavor development, a number of these aldehydes were synthesized in the laboratory for comparison with identified compounds from the potato products. Closely related compounds were also synthesized and evaluated to compare flavor with the natural compounds. The synthetic approach is providing basic information that will help lead to identification of compounds now separated from the volatiles of potato products but not absolutely identified.

Subjective evaluations of flavor are being made on purified organic compounds that are found in food volatiles and believed to be related to product flavor. A trained test panel determines odor thresholds of aqueous solutions of these substances. This is one phase of the systematic approach to provide correlations between the chemistry of volatile compounds and the flavors of food. In order to study the effect of mixed systems, several compounds have been put together in sub-threshold concentrations and evaluated. Preliminary studies indicate an additive relationship between chemical components and olfactory response. Thus, the aroma threshold of a ten-component mixture was identified by a test panel when each of the components existed at one-tenth of its individual threshold concentration. This finding is an early step toward interpreting in terms of flavor the complicated chromatograms obtained in advanced chemical studies.

2. Enzymic Browning. Fundamental studies on the enzymic browning of potatoes are in progress at the Low Temperature Research Station at Cambridge, England, supported by a grant under Public Law 480. This research is aimed at determining the nature, distribution, and mode of action of enzymes responsible for enzymic browning of potatoes and potato products and, further, determining the nature and distribution of phenolic substrates and pathways of their synthesis. During maturation of potato tubers, they pass through a phase in which there is unequal browning of the cut surface. In these immature tubers the browning is confined almost entirely within the vascular ring, the tissue outside the vascular ring browns only slightly. Analyses were made of the concentration of tyrosine, the concentration of the phenolase enzyme, and the susceptibility to enzymic discoloration across the cut surface of such tubers. Data obtained confirmed earlier work that indicated a close correlation between the tyrosine content and the degree of enzymic discoloration, but a less close correlation between the concentration of the enzyme phenolase and browning. Further, the experiment confirmed that the concentration of the other major phenolic constituent, chlorogenic acid, little influences the susceptibility of the cut surface to discoloration because of its light-colored oxidation product. A simple

experiment showed that if another enzyme substrate is applied across the entire tuber surface, then the browning is as rapid in the tissue outside the vascular ring as inside it, confirming that concentration of the enzyme is not limiting the rate of browning. The differential distribution of tyrosine disappears before the tuber reaches maturity, so that browning is then uniform over the cut surface.

With this knowledge in hand it is possible that effect of climatic, cultural, or kinetic factors on enzymatic browning may be studied in terms of the influence of these factors on the synthesis of tyrosine in the growing tuber. Greenhouse studies indicate certain fertilizer enrichment programs that can increase the concentration of tyrosine as much as three times. Fundamental studies of the biosynthesis of phenolic compounds and enzymes related to their formation are in progress.

3. The Role of Sulfur Dioxide in Dehydrated Vegetables. A basic investigation to determine the chemical mechanism of the protective action of sulfur dioxide to control browning in dehydrated vegetables is being conducted at the Covent Garden Laboratory in London, England, supported by a grant under P.L. 480. As this program approaches completion, excellent progress is shown by publication of eight scientific papers already, and with more on the way. Without adequate protection, many dehydrated fruits and vegetables gradually become brown, develop objectionable flavors and odors, and suffer losses in nutritive value. While the most common way to avoid these effects has been to treat the products with sulfur dioxide during processing, until recently very little has been known about the mechanism of this treatment. It has long been known that chemical browning reaction occurs between sugars and amino acids. This chemical reaction is being greatly clarified. When sugar solutions are heated, configurational changes occur, developing unsaturation in the sugar molecule. The rate of browning of such solutions depends on the ease of dehydration of the sugar-derived compounds and upon the reactivity of intermediates produced. These factors depend upon the molecular configuration of the sugar present initially and on the environment. Where sulfite is added to prevent discoloration of sugar and amino compounds, it has to deal not only with the initial sugars but also with the new compounds formed. Sulfite reaction with the initial sugar hinders the formation of some of these new compounds whose reactivity in terms of discoloration is greater than the initial molecular configuration of the sugar present. This new knowledge provides a basis for developing new methods for protecting dehydrated fruits and vegetables from non-enzymic browning, where sulfur dioxide is not satisfactory or its use must be limited.

B. Technological and Engineering Research on New Products and Processing Methods

1. Dehydrated Potato Granules. In the production of instant mashed potato powder, a major problem exists in the translation of laboratory results to plant scale, especially in the reduction of potato from a wet mash to a

coarse moist powder. The moist powder must be separated into individual cells or small cell clusters without undue rupture of cell walls and must not reagglomerate before or during subsequent finishing drying. Although many processes have been reported during the past 40 years, only processes involving add-back of previously dried materials have been successful for commercial production of high density granules. Research over the past several years has been conducted to develop a direct process involving three phases of drying: (1) an initial partial drying to about 55 to 60% moisture content; (2) an intermediate drying operation combined with simultaneous mixing of the product, and (3) a finish drying step. The initial drying has been performed by either of two techniques; drum drying of cooked mash, or through-flow conveyor drying of cooked half-inch cubes. In order to progress to the moist coarse powder stage a freezing and thawing operation has been used between the first two drying phases. After thawing, the intermediate drying operation has been performed in a specially designed trough-type dryer in which the product is continuously and gently mixed. New equipment has been designed in this investigation, including a continuous potato ricer, a through-type granulator-dryer, and granulating rolls. Descriptions of this new equipment have been made available for commercial potato processors to evaluate in connection with their potato drying processes.

PUBLICATIONS AND PATENT REPORTING RESULTS
OF USDA AND COOPERATIVE RESEARCH

Chemical Composition Related to Flavor, Color, and Texture of Potato Products

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Technological and Engineering Research on New Products and Processing Methods

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UTILIZATION RESEARCH AND DEVELOPMENT
Eastern Utilization Research and Development Div., ARS

Problem. The potato industry, faced with a continuing decline in the consumption of fresh potatoes, is becoming more and more dependent upon the development of new and improved processed products to maintain markets and to avoid recurring economic disasters. Crop perishability, supply fluctuations, and the inelasticity of demand, result in wide swings in price with even slight surpluses. In producing areas having a substantial processing industry, depressive lows are moderated by advance contracting by processors prior to harvest. However, in many important potato growing areas processing has not yet developed, and vulnerability not only still exists, but is exaggerated by the growing competition of processed potato and other competing food products. A continuing improvement in processed potato products is clearly required if processing is to expand fast enough to offset the progressive decline in use of fresh potatoes.

Lack of adequate knowledge concerning the chemical constituents, physical properties, and enzyme systems in potatoes is limiting development of new and improved processed products and processing methods. Basic research on composition is needed to provide fundamental information on which an applied research program can be systematically and effectively built. Recently-developed techniques make it possible to isolate and characterize the constituents responsible for flavor, color, odor, and texture of many processed food products. Application of these techniques to potatoes and potato products should make it possible to improve the quality of present products, both freshly processed and following storage, and provide a basis for technological and engineering studies in new product development.

USDA PROGRAM

The Department has a continuing long-term program of basic and applied chemical and engineering research on studies related to processing. The work of the EURDD, involving the services of chemists, biochemists, food technologists and chemical engineers at Wyndmoor, Pennsylvania, is conducted in cooperation with the Maine Agricultural Experiment Station and several other stations, which supply potatoes of known cultural history. The chemical research program includes: evaluation of the effects of variety, location of production, storage conditions, and tuber solids content on potato composition with particular respect to nitrogenous constituents; principal acids and other factors related to discolorations such as after-cooking discoloration; preliminary studies on the lipids, which are believed to occupy an important role in storage stability of processed potato products, particularly dehydrated foodstuffs. The Eastern Division's engineering and development research program seeks to improve the quality, nutritive value and storage stability of dehydrated potato products and to develop more convenient types of dehydrated products, such as "instantized" pieces that cook quickly. The Eastern Division is now planning the establishment of a Potato Processing Laboratory in the Red River Valley, the purpose of which will be to conduct

investigations relating variety and other raw material characteristics to quality of established forms of processed potatoes. This new Laboratory will be operated jointly by the Red River Valley Potato Growers Association, University of Minnesota, North Dakota State University and the Agricultural Research Service with the Engineer-in-Charge reporting to Wyndmoor.

The Federal (Eastern Division) scientific effort devoted to research in this area totals 14.4 professional man-years. Of this total, research on chemical composition as related to processing characteristics comprises 7.8 p.m.y. During the year a new line of work was initiated in which the potato after-cooking discoloration pigment will be isolated and studied. Research was started on potato lipids. Research on dehydrated potato products constitutes 2.7 p.m.y. Research on new and improved processing technology amounts to 3.9 p.m.y.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition as Related to Processing

1. Nitrogenous constituents. Samples of 5 leading potato varieties (Katahdin, Russet Burbank, Kennebec, Red Pontiac and Cobbler) grown in 6 of the country's principal producing areas (Maine, New York, Pennsylvania, Red River Valley area, Wisconsin and Idaho) in 1961 and 1962 were analyzed. Great differences in composition were found between varieties and within a given variety grown in different locations and in different years. Major changes in the nitrogen pattern during storage appear to occur in asparagine and glutamine. Results of taste panel studies are being statistically analyzed in the attempt to correlate taste with composition.

Potato protein fractions have been separated into at least 12 bands by gel electrophoresis. This definitely indicates that more potato protein fractions exist than just tuberin and tuberinin, commonly reported in the literature.

Work has been continued on the subject of sugar-amino acid compounds formation in potato chip frying. At least 5 compounds of this type have been tentatively identified as being formed during chip-frying.

2. Basic studies on the after-cooking discoloration pigment. A statistical study was made on potato organic acid data obtained under a previous project (E3 6-27). Valid inverse correlations were found between after-cooking discoloration and organic acid content, particularly with citric acid but also with orthophosphoric acid plus oxalic acid. Analytical data indicate that a protein-iron complex may be an important factor in after-cooking discoloration. Addition of ferrous iron to precipitated, denatured protein causes the latter to turn from white to light gray. This color change is irreversible with HCl, but citric acid addition changes the gray back to white. Addition of chlorogenic acid to the protein-iron complex intensifies the light gray to black. Chlorogenic acid added to potato protein in the absence of iron, however, causes no darkening. These observations on induced blackening support

the idea that the combination of ferrous iron, chlorogenic acid, and potato protein is involved in after-cooking discoloration.

3. Basic studies on potato lipids. The first phase of work under this new project has been concerned with obtaining and evaluating new equipment, extraction techniques, and methods of resolving complex mixtures of lipids. Since the unsaturated potato lipids are very susceptible to oxidation during ordinary drying by heat, extraction of fresh tissue has been tried in the attempt to circumvent use of dried potato. This has led, however, to high values due to extraction of nonlipid substance. Experiments are being made in drying potato tissue under very mild conditions, with exclusion of oxygen, to prepare material for organic solvent extraction of lipids. Thin-layer chromatography experiments on crude potato lipid fractions are now in progress.

B. Dehydrated Potato Products

1. "Instantized" pieces. It is believed that a great potential exists for dehydrated potato pieces that will rehydrate more rapidly than the conventional product. Methods have been developed for partially drying the pieces, rendering them porous by quick pressure buildup in a "gun" followed by sudden release to atmospheric pressure, and finally drying the porous structure to low moisture content. Initial drying of the potato dice (nominally 3/8-inch cubes) is carried out at 180° - 200° F. "Explosion-puffing" of potato dice is best carried out at about 35-40% moisture content and 55-65 p.s.i.g. to maximize uniformity of structure and speed of rehydration. "Instantized" dehydrated pieces will reconstitute in less than 5 minutes in boiling water as compared with 20-30 minutes for present commercial dice. Future research is to be directed toward such factors as "instantizing" of larger pieces, increasing product yield, evaluation of a larger pilot plant puffing gun, study of major potato varieties as raw material, and storage characteristics of the products.

C. New and Improved Processing Technology

1. Potato flakes and flakelets storage. Since the FDA would prefer a limit on the concentration of BHA plus BHT antioxidants in flakes lower than that considered by the industry as optimum for best storage stability, it has become advisable to search for other means of imparting storage stability. Flakelets packed in nitrogen without antioxidant, in a 9-month storage test, kept at least as well as the same product packed in air and containing 23 ppm of BHA plus BHT. Since flakelets can be made without antioxidant and packed in nitrogen cheaper than flakes can be made containing antioxidant and packed in air, the former higher-density product is especially well adapted to military, institutional and export use. Tests on the use of tocopherols to protect against oxidation have been discouraging due to the fact that the tocopherols contribute an off-flavor.

2. Technological research in processing. A limited amount of exploratory work has been conducted on chemical and physical properties of potatoes that

influence the color and texture of frozen French fries. A recording attachment has been obtained for the L.E.E.-Kramer shear tester. Attempts are being made to correlate the peaks in the load vs. resistance (to deformation) curve with texture and other characteristics of raw and French fried slices.

PUBLICATIONS AND PATENTS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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New and Improved Processing Technology

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NUTRITION AND CONSUMER USE RESEARCH

Consumer and Food Economics Research Division, ARS
Human Nutrition Research Division, ARS

Problem. The assortment and characteristics of foods available to consumers are constantly changing with the adoption of new production, processing, and marketing practices. Constantly changing also, as nutrition science advances, is our understanding of the nutritional needs of man and the manner in which these needs can best be met by food. To help carry out the Department's responsibility to advise on the quantity and variety of foods that will assure maximum benefit and satisfaction to consumers, continuous research is essential on the nutritional requirements of persons of all age groups, and on the nutrient and other inherent values of foods and how to conserve or enhance these values in household preparation and processing. Periodic examinations of the kinds and amounts of foods consumed by different population groups and individuals also are essential for evaluation of the nutritional adequacy of diets and to give the guidance needed for effective nutrition education. Such information provides assistance needed in market analyses for different commodities and in the development and evaluation of agricultural policies relating to food production, distribution, and use.

USDA PROGRAM

The Department has a continuing program of research concerned with (1) nutritive and other consumer values of raw and processed foods as measured by chemical or physical means and by biologic response; (2) effects of household practices upon the nutritive values and inherent qualities of foods, and the development of principles and improved procedures for household food preparation, care and preservation; (3) surveys of kinds, amounts, and costs of foods consumed by different population groups and the nutritional appraisal of diets and food supplies; and (4) development of guidance materials for nutrition programs.

The research is carried out by two divisions of the Agricultural Research Service--the Human Nutrition and the Consumer and Food Economics Research Divisions. Most of the work is done at Beltsville, Maryland and in Hyattsville, Maryland; some is done under cooperative or contract arrangements with State Experiment Stations, universities, medical schools, and industry. The total Federal scientific effort devoted to research in these areas totals 66.3 man-years. It is estimated that approximately 1.2 man-years is concerned with studies related to potatoes and potato products.

Human metabolic studies and the related exploratory and confirmatory studies with experimental animals and microorganisms concerned with defining human requirements for nutrients and foods are not reported on a commodity basis,

though some of the work is applicable to this report. This basic nutrition research represents a total Federal effort of 23.4 professional man-years and is described in detail in the report of the Human Nutrition Research Division. Certain aspects of this research related to horticultural crops are considered briefly in this report.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Nutrient Values of Potatoes

1. Tables of food composition. The 1963 revision of Agricultural Handbook No. 8, "Composition of Foods...Raw, Processed, Prepared," was completed and carried through to the galley proof phase. Data for potatoes are given under five major subheadings, raw, cooked, canned, precooked dehydrated, and frozen. Data for potatoes cooked according to 10 different methods of preparation are listed separately. Data for flake and granule "instant" potatoes are shown for the dehydrated and for the ready-to-serve forms. A few soups and baby foods containing potatoes are also included in the new edition of the tables.

Data in the popular publication, "Nutritive Value of Foods," Home and Garden Bulletin No. 72, have been revised to agree on a weight basis with nutritive values in Handbook No. 8. The revised edition will provide nutritive values of household measures of 512 commonly used foods. Another popular publication, "Conserving the Nutritive Values in Foods," Home and Garden Bulletin No. 90, is in press.

2. Vitamin analyses. Research continued on procedures useful for B-vitamin analyses to permit characterization of B-vitamins in potatoes and other foods and to determine their overall distribution in the food supply. A procedure has been developed for the quantitative determination of pyridoxine (vitamin B₆) as pyridoxal cyanohydrin. Studies will be continued to apply this chemical procedure to the assay of vitamin B₆ in food extracts and to verify results by comparisons with those of the microbiological assay. An improved method for thiamine determination also has been developed. The conditions of the 6-aminothymol colorimetric reaction were changed so that a stable fluorescent compound was produced with thiamine. The fluorescence made possible measurements at much lower concentrations and appeared to be simpler than the usual thiochrome reaction.

3. Proximate composition. Work is underway to determine the moisture, fat, Kjeldahl nitrogen and ash content of several prepared frozen, canned and packaged potato products. Analyses are being made on products as purchased and as prepared for serving. This is part of a study to determine the dietary contribution of commercially prepared foods.

B. Properties Related to Quality and Consumer Use of Potatoes

1. Food buying guides for school lunch managers. A revision of PA-270, "Food Buying Guide for Type A School Lunches," was completed in cooperation

with the Agricultural Marketing Service. New data were added to the 1955 edition and the format was changed to make the guide more usable by school lunch managers participating in the National School Lunch Program.

2. Food buying guides for families. Work has been initiated on a food buying guide for family use.

C. Nutrient Functions

Carbohydrates. Basic research using small animals and microorganisms is contributing to an understanding of the influence of type of carbohydrate on lipid and protein metabolism and to our knowledge of factors influencing the physiological response to carbohydrate-containing foods such as potatoes.

Protein components in the blood serum of rats, particularly rapidly moving components (PA), varied with diet and with age. PA was present more often and in larger amounts with fasted rats fed a sucrose-containing diet than with rats of comparable age on a starch-containing diet. With either carbohydrate (sucrose or starch), more PA was generally present in the serum of 350 day-old rats than in that of 150 day-old animals. With glucose, PA was present in small amounts in a larger percentage of rats, and no age effect was apparent. The percentage of 150 day-old, sucrose-fed rats with serum containing PA was higher in nonfasted than in fasted rats; the reverse was observed with glucose. Lipid material was found in the PA components. The presence and amount of these components may provide an additional means of measuring response to diet and may prove a valuable tool for studying lipid transport.

D. Requirements for Nutrients

1. Preadolescent age group. Cooperation has continued with experiment stations in the Southern Region (S-28 revised) for investigation of metabolic patterns and for assessing requirements for and utilization of selected nutrients by preadolescent children. In 1962, at Blacksburg, Virginia, 12 preadolescent girls were maintained on controlled diets with variation in the amount of protein (entirely from plant sources). Potatoes were included in the diets. Analyses completed for intake and outgo of fat suggest that the amount of fecal fat excreted by the subjects was about twice the amount of fat excreted by subjects on controlled diets in earlier studies, where the protein was mainly from animal sources, although the content of total fat in the diets was comparable.

2. Adolescent age group. A study of nutritional needs of adolescents was conducted under contract at Berrien Springs, Michigan, with a group of adolescent girls, 16 to 19 years of age. The controlled diet used was designed to measure the metabolic response to an ovo-lacto-vegetarian type of diet. Potatoes were included in the experimental diet. The major portion of the dietary fat was provided by butter and corn oil. The study will provide data on intake and outgo of nitrogen, fat, and selected minerals, and on blood lipid patterns for use in assessing nutritional requirements of adolescent

girls. To obtain data for a more representative group of girls on an ovo-lacto-vegetarian type of diet, a replicate study is being planned with another group of 16 to 19 year old girls. Long-range plans include studies with younger adolescents using controlled diets with different combinations of food and different levels of nutrients.

E. Food Consumption and Diet Appraisal

1. Food consumption and dietary levels. A report of the findings of the food consumption survey of beneficiaries of Old Age and Survivors Insurance made in Rochester, New York in the spring of 1957 has been completed. The survey included 283 1- or 2-person households. During the survey week, food brought into the kitchens of these households averaged about the following amounts per person: 4 quarts of whole milk or its equivalent in milk products; 4 pounds of meat, poultry, fish; 1/2 dozen eggs; 10 pounds of vegetables and fruits; 2 pounds of grain products (in terms of flour); 1 pound of sugars and sweets; and 3/4 pound of fats and oils. The total money value of all food per person was \$8.12. Nutrients from this food more than met the National Research Council's recommended allowance for the average person. However, less than half (44 percent) of the households had diets which met in full the recommended amounts for all nine nutrients (good diets). Nearly three-fourths of the households had diets that met two-thirds of the recommendations for all nutrients (good and fair diets). The nutrients which fell below the recommended allowances most often were thiamine and calcium.

The series of food surveys conducted in low-income areas to aid in the study of the effects of food distribution programs on diets of families has been extended to include a survey carried out in Choctaw County, Oklahoma and in Pensacola, Florida. These were conducted cooperatively with the Marketing Economics Division, Economic Research Service as were similar surveys reported previously.

A food consumption survey was carried out in the District of Columbia that will provide information on the diets of households and of individuals. The study was undertaken primarily as a pilot survey in developing procedures for the next Nationwide survey proposed in the Department's long-range program.

The nutrient content of the per capita food supply is calculated and published each year, using data on estimated quantities of foods consumed (retail-weight basis) as developed by the Economic Research Service. This series, with estimates extending back to 1909, is the only source of data on year-to-year changes in the nutrient content of the U. S. per capita food consumption.

2. Food management practices. The results from three small studies based on records kept by the homemaker on the kind, amount, and nutritive value of foods used and discarded in households have been prepared as a journal article. In terms of total calories available for consumption, discarded edible food averaged 7 percent in St. Paul, Minnesota; 8 percent in DeKalb County, Missouri; and 10 percent in Los Angeles, California. A study using

"recall questions," instead of records, with a random sample of 300 households in Minneapolis-St. Paul in the winter of 1960 is currently being processed.

A report on household practices in handling and storing commercially frozen foods, based on surveys in two cities has been published. Survey findings indicate that household practices alone would not cause serious quality deterioration of frozen foods.

A new study has been initiated (under contract) of the management practices of urban and farm home freezer owners in Fort Wayne, Indiana and a nearby rural area. The survey is designed to obtain information on such actual management practices of home freezer owners as the kinds, amounts, sources, prices, and rate of turnover of foods frozen and stored in the home.

3. Development of food budgets and other basic data for food and nutrition programs. The ongoing program of interpretation and application of nutrition research findings to practical problems for use by nutritionists, teachers, health workers, and other leaders concerned with nutrition education or nutrition policies has involved the preparation or review of articles and publications, talks, television interviews, and participation in various conferences and committees.

With the publication of the report "Family Food Plans and Food Costs" the technical work on the development of the Department's current low-cost, moderate-cost and liberal food plans was completed. The continuing phases of the work on individual and household food budgets consists in the regular pricing of the food plans for publication in Family Economics Review, and in dissemination of information concerning them through such popular publications as "Family Food Budgeting for Good Meals and Good Nutrition," through filmstrips ("Food for the Young Couple"), and through correspondence, talks and committees (such as the Advisory Committee to the Bureau of Labor Statistics on their City Workers' Standard Budget).

Progress on the revision of Handbook No. 16, "Planning Food for Institutions" has focused primarily on the food purchasing guide section. Publications in preparation that are designed for the use of teachers, extension workers and other leaders are (1) a semi-popular publication on nutrition in the series Facts for Nutrition Programs, (2) a report on fat and related components in U. S. diets, and (3) a study of the relative economy of foods.

Nutrition Committee News, a bimonthly periodical prepared for members of State nutrition committees and other workers in nutrition education provides one channel for disseminating pertinent information and for reporting nutrition education activities. Examples of subjects of current interest covered during the report period are: "Nutrition Aspects of Selected Studies of Cardiovascular Diseases--Implications for Nutrition Education," "Planning Nutrition Programs for Elementary School Teachers," and "Food Guides--A Teaching Tool in Nutrition Education."

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III MARKETING AND ECONOMIC RESEARCH

MARKET QUALITY

Market Quality Research Division, AMS

Problem. The problems arising from the number of potato varieties grown, areas of production, seasons of harvest and special storage and handling requirements for specific uses require a continuing program of research on handling, storage, transportation, physiology, wastage control and quality measurement. Current emphasis on processing has created special problems in prolonged storage at elevated temperatures and protection from low temperatures in transit. This has substantially increased the need for research on the control of moisture loss and the reduction of bacterial and fungal decay. Higher temperature storage also involves control of sprouting, with increased emphasis on chemical sprout inhibitors. There are also major problems in the area of quality measurement. Objective indices are needed to identify quality factors that are important for specific product usage. Contemplated increased use of federal grades for processing potatoes has resulted in need for more information to relate characteristics of the raw product to quality of the processed product. Also needed are non-destructive methods and instruments for detecting and rejecting potatoes with internal disorders during grading.

USDA PROGRAM

The Department has a continuing long-term program involving horticulturists, plant pathologists and plant physiologists engaged in applied and basic research. The work at East Grand Forks, Minnesota is conducted in cooperation with the Minnesota and North Dakota Agricultural Experiment Stations and the Red River Valley Potato Growers Association. The work at Presque Isle, Maine is in cooperation with the Maine Agricultural Experiment Station. Research on transportation of early potatoes for chips is conducted by the Fresno, California station. The studies at Beltsville involve specialized storage problems and basic research. Studies on market diseases are conducted at Chicago and New York City.

The federal scientific effort devoted to research in this area totals 6.0 professional man years. Of this number 0.5 is devoted to objective measurement of quality, 0.5 to handling and packaging, 1.5 to storage, 0.5 to quality maintenance during transportation, 0.5 to postharvest physiology, 2 to postharvest disease control, and 0.5 to program leadership.

Work terminated during the reporting period included studies on pre-cut seed (MQ 2-5), storage and chipping quality of new varieties (MQ 2-8), low temperature effects on seed potatoes (MQ 2-19), ventilation of storage in relation to quality of Maine potatoes (MQ 2-35), internal black spot (MQ 2-37), bin vs. box storage (part of MQ 2-39), and decay as related to previous storage temperature.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement of quality

1. Determining Susceptibility to Bruising. Investigation of the relationship of susceptibility of potatoes to bruising and physical properties was continued at East Grand Forks, Minnesota. An impact instrument developed in cooperation with ARS was tested to determine the relative susceptibility to injury of different lots of potatoes. The results obtained this season were inconclusive and indicated a need for modification of the testing technique. A device has been built to simulate commercial handling and is currently being tested.

B. Quality maintenance in handling and packaging

1. Mechanical Injury Incident to Sizing Potatoes into Storage. Although about 50 percent more bruising occurred in Red River Valley potatoes (Red Pontiac variety) sized into storage than those not sized, the bruising was largely confined to non-grade defects. This confirms work done previously with Norlands.

C. Quality maintenance in storage

1. Influence of Storage Temperature on Processing Quality of Potatoes. Irish Cobbler, Kennebec, Red Pontiac, and Snowflake potatoes were stored at 40°, 45° and 50° F. at East Grand Forks, Minn. The potatoes stored at 45° and 50° were treated with CIPC to inhibit sprouting. At monthly intervals for 10 months, 300-lb. lots were removed from storage for pilot plant processing into flakes and slices. The potatoes stored at 40° and 45° were reconditioned for 3 weeks at 60° to 70°. Satisfactory flakes were produced from all lots of potatoes throughout the storage period. Data for slices are not yet available. There was no consistent relationship between storage temperature and shrinkage. CIPC volatilized into the storage space successfully controlled sprouting at 45° and 50° for the entire storage period.

2. Standards for Processing Potatoes. Spectrophotometric measurements were made at Beltsville, of color standards for typical potato chip colors. The spectral curves were reduced to trichromatic

coefficients. From the coefficients, Munsell rennotations were prepared for the Fruit and Vegetable Division for possible inclusion in their revised grade standards for potatoes for processing. Repaints, in the Munsell Book of Color having notations close to those calculated, compared well visually. The designations for the potato color standards could be specified in the grade standard. Color could be obtained for use by both potato chip and french fry manufacturers.

3. Effect of Methods and Rates of Ventilation on Quality of Maine Potatoes. The air flow occurring at various locations within the bins was measured with new equipment. The most uniform air flow condition occurred at about 2 cfm per bbl. At higher rates the air movement became uneven within the pile.

The highest air flow rate (4 cfm/bbl.) gave best control of storage soft rot, whereas the intermediate rates (1, 1½, and 2 cfm/bbl.) showed considerable variation. Apparently at these intermediate rates the moisture is removed from the bottom of the pile and redeposited in the upper layers resulting in greater rot development. This condition has varied with the season and the crop condition.

4. Deep Bin vs. Pallet Box Storage. Nearly 20% of the potatoes were damaged when harvested into a hopper body and placed in a bin with a bin loader as compared to less than 1% damage when harvested into pallet boxes. Federal-State inspection showed 2.4% grade defects due to mechanical bruising in potatoes stored in the bin lot as compared to 1.3% in the pallet boxes. Silver scurf covered one-quarter or more of the tuber surface of 12.3% of the potatoes from bin storage as compared to 5.9% of the tubers from pallet box storage. (See also 9-F-5). This work has been completed.

5. Internal Sprouting. In the 1962-63 season potatoes dipped in 0.5% CIPC suspension at Beltsville developed neither external nor internal sprouts during 18 weeks at 62° F. Untreated Katahdins stored in the same chamber with the dipped potatoes, developed 0.4 lbs. external sprouts per hundredweight of tubers and 1% internal sprouting, while untreated Irish Cobblers developed 1.4 lbs. external sprouts per cwt. and 10% internal sprouting. In the same building but in a separate room from the dipped potatoes in chambers, untreated Katahdins developed no internal sprouting while untreated Irish Cobblers developed 6.4% internal sprouting. All sprouting in this building which contained CIPC treated potatoes was of the appressed rosette type. Potatoes in chambers in a separate building used entirely for potato seed storage developed a different type of external sprout growth with sprouts mostly over 2 feet long and none of the appressed rosette type. Only one Katahdin tuber (.2%), in the CIPC-free building, developed internal sprouting through a crack near an eye. External sprouts averaged 7.8 lbs. per cwt. of Katahdin tubers

and 14.6 lbs. per cwt. of Irish Cobbler tubers.

6. Application Methods of CIPC. The 1962-63 study in Maine indicates that moderate air flow rates from 1 to $1\frac{1}{2}$ cfm per bbl. resulted in more uniform distribution of the inhibitor within the pile than higher or lower rates. Residue analysis indicates no apparent residue problem when the recommended rates are applied. The highest residues were at the high air flow ($2\frac{1}{4}$ cfm/bbl.)

Treated tubers held in storage for 160 days had almost complete sprout inhibition but some rosette-type sprouts were present on tubers at the bottom and along the edges of the pile. A few internal sprouts were in the initial stage of development but the percentage of affected tubers was very low. The tubers were firm and the quality good.

CIPC was applied to tubers stored in pallet boxes with good sprout inhibition and no internal sprouting.

Emulsifiable CIPC was applied to skinned tubers of several potato selections with little or no effect upon the formation of wound periderm in storage.

D. Quality maintenance during transportation

1. Transit Temperatures of California Potatoes. California-grown Kennebec potatoes for chip manufacture, harvested at different times during the season appear to have different transit temperature requirements. Potatoes harvested during May and early June produced chips with satisfactory color when held at relatively low temperatures (55 to 65° F.) for 5 and 9 days. Potatoes harvested during late June produced darker chips when held at 55 or 59° F. than when held at 65, 70 or 75° F. Potatoes that produced dark chips after 5 or 9 days could not be reconditioned by holding an additional 4 days at 75° F.; rather, they generally produced even darker chips after this treatment. Holding potatoes at 75° rather than 70° F. during simulated transit did not improve chip color.

Kennebec potatoes are frequently shipped to the midwest under Standard Ventilation during the early part of the season when ambient temperatures are relatively low enroute. Transit temperatures of two rail cars of Kennebec potatoes shipped under Standard Ventilation averaged 64° F. during late May and early June. This temperature appears to be satisfactory for early season potatoes under this year's growing conditions. White Rose potatoes were hydrocooled in a flood-type hydrocooler to determine the rate of cooling. The half-cooling time for 2-inch diameter potatoes completely exposed to the water or jumble stacked (5 layers high) was 11 minutes.

2. Relation of Oxygen and Carbon Dioxide to Decay. In tests with high nitrogen, low oxygen atmospheres at Harlingen, Texas, Lasoda

potatoes had 10 percent bacterial soft rot following exposure for 10 days to less than 1 percent oxygen either with or without an absorbent for carbon dioxide. Negligible rot occurred when oxygen was $2\frac{1}{2}$ percent or higher. As expected, low oxygen increased sprouting.

E. Postharvest physiology

1. Suberin Formation. Shikimic, ferulic, and chlorogenic acids, eugenol, hydrogen peroxide, catechol, P-cresol and phenylthiourea were tested for their effect on suberin development on slices of Irish potatoes during 2 days' holding at 70° F. in moist chambers. Only slices treated with phenylthiourea at 5×10^{-3} M consistently developed a better suberized layer than untreated slices. Its effect in increasing this barrier was more pronounced on slices of Katahdin than on Irish Cobbler, Pontiac, or Idaho Russet Burbank.

F. Postharvest disease control

1. Pre-storage Washing. Maine potatoes were washed at harvest, 1 month after harvest, and during the winter just before marketing. Those washed in the fall were held in storage for winter marketing. Only 51 percent of the potatoes washed at harvest were marketable by winter. Fifty-eight percent of those washed 1 month after harvest were marketable while 63 percent washed during the winter were marketable. Lenticel infection was about twice as great in the fall-washed potatoes as in those washed in the winter.

2. Decay as Related to Previous Storage Temperature. The effect of chilling on the phenolic metabolism and susceptibility of Katahdin and Kennebec potatoes to fusarium decay was investigated at the New York Market Pathology Laboratory. Tuber slices stored at 32° F. for 10 weeks were more susceptible to decay when held at 70° F. than slices of potatoes stored at 40° F. or 52° F. Kennebecs were more susceptible than the Katahdins when stored at 32° F. After 6 days non-inoculated cut tissue of tubers from 32° storage contained 54% more O-dihydric phenols than non-inoculated cut tissue from 40°. Inoculated cut tissue of tubers from both storage temperatures accumulated O-dihydric phenols at a slower rate than non-inoculated cut tissue. Diffusates from cut tissue of tubers stored at 32° F. promoted more germ tube growth of conidia of Fusarium solani, f. radicola after twenty-four hours than diffusates from cut tissue of tubers stored at 40° F.

3. Internal Black Spot. Data from the 1962-63 storage studies in Maine showed a high incidence of pressure bruising but little internal black spot in all treatments. Various field-applied fungicides had no significant effect on the development of internal black spot in tubers which had been held 6 months under 500 psi pressure at 38° F. and

95% R.H.

A higher percentage of potatoes developed pressure bruising in deep bin storage than in pallet boxes. No internal black spot developed in pallet boxes, whereas 10 percent of the potatoes from the deep bin developed internal black spot. No internal black spot was found in the non-pressure bruised tubers.

4. Phoma in Potatoes. Phoma sp. was isolated from Maine potatoes in the Chicago market in 1963. Most of it occurred beneath bruised areas. Optimum growth of the organism on potato dextrose agar occurred at 68° F. Spore germination and cultural growth was inhibited at temperatures in the range 82-86°. Minimum temperature for growth of agar-mycelium transplants was 36°. No growth occurred on single spore inoculated plates held at 40°.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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TRANSPORTATION AND MARKETING FACILITIES

Transportation and Facilities Research Division, AMS

Problem. Returns to producers and prices paid by consumers for potatoes are adversely affected by the use of inefficient marketing facilities, equipment, and methods. Better work methods, techniques, devices, operating procedures, equipment, and facility designs are needed for pre-cooling, conditioning, storing, handling, cleaning, washing, waxing, sorting, sizing and packing potatoes. Such improvements are needed at both shipping points and terminal markets. They would increase the productivity of labor, prolong the storage life of the commodities, reduce bruises and injuries to these products, reduce marketing costs, expand consumption, and reflect greater returns to producers.

It costs about 8 billion dollars a year to package food products, but without shipping containers and various other types of packages it would be impossible to move farm products efficiently from the widely dispersed areas of production through our complex marketing system to millions of consumers. New or improved packages and containers must be developed and evaluated to do this job more effectively. Continuing changes characterized the American marketing system. In protecting, distributing and selling perishable agricultural commodities, packages and containers must respond to a number of marketing system changes. Packages and containers not only respond to changes, but changes in them stimulate improvements in other elements of the marketing system. The job of the research program in this area is to see that packages and containers keep pace with changes in the marketing system and reduce the cost of handling, transporting and storing agricultural commodities. It also seeks to improve service to consumers, promote greater sales of farm products, and increase the income of producers.

It costs several billion dollars each year to transport farm products over the great distances between growing areas and consumers. In bridging this distance, products must normally be transported several times (farm to local assembly market, to warehouse, to terminal market, and thence to retail stores). Rail, truck, air, and water transport are used. Without this transportation, farm products would be worth little to farmers and nothing to consumers. Despite its importance, less has been done to improve the efficiency of transportation than for other aspects of marketing or farming.

USDA PROGRAM

This is a continuing long-range program involving engineering research covering the development of improved work methods, techniques, devices, operating procedures, equipment, and facility designs for precooling, conditioning, storing, handling, cleaning, washing, waxing, sorting, sizing and packing. Potato research is carried on at the Red River Valley

Potato Research Center, East Grand Forks, Minn.; the Maine Potato Research Center, Presque Isle, Me.; a field office at Gainesville, Fla., and the Washington office; in both laboratory and commercially-owned facilities; in North Dakota, Minnesota, Maine, Idaho, and Florida; in cooperation with the North Dakota, Minnesota, Maine, Idaho, and Florida Agricultural Experiment Stations, the Red River Valley Potato Growers' Association, the Market Quality Research Division, the Marketing Economics Division of ERS, the Harvesting and Farm Processing Branch, Agricultural Engineering Research Division of ARS, and the Forest Products Laboratory of the Forest Service. The current Federal effort devoted to research in this area totals 12.3 professional man-years of which 4.3 is on potatoes.

This is a continuing program of applied research conducted by marketing specialists, industrial engineers, and agricultural economists to (1) develop new or improved consumer packages, master containers, packing materials, and shipping containers for agricultural products; (2) evaluate them from the standpoint of cost of materials and direct labor to pack, and their ability to reduce product damage and increase product salability; (3) determine at which point in the marketing system packaging can be done most effectively; (4) improve the efficiency of packaging methods to cut costs; (5) and investigate the needs for and benefits of container standardization and simplification. The program was carried on in cooperation with the Experiment Stations and industry in Alabama and Florida, at the Orlando branch field station and in the principal terminal markets. The work utilized 0.5 professional Federal man-years.

The Department has a continuing program of economic-engineering research in agricultural transport. Its purpose is to develop improved transport facilities, equipment and services and more efficient means of using them in the production and marketing of agricultural products. Almost all the work is carried out in cooperation with various industry groups, trade associations, State Universities and experiment stations. Only one field station, Orlando, Florida, is permanently maintained for transport research. All other field work is carried out from the Washington office. Part of the research under this program is conducted under contract and cooperative agreements. The work on potatoes utilized 0.5 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Handling and Packing

1. Presque Isle, Me. Research under this project, which is cooperative with the Maine Station, is directed toward reducing operating costs of potato storages and packinghouses by increasing the productivity of labor employed and reducing losses from bruises and mechanical injuries in handling, storing, cleaning, grading, sizing and packing potatoes. It involves the development of more efficient work methods, operating procedures, equipment, and facilities for handling, storing, and preparing for market Maine potatoes.

Grading studies on the experimental float-roll sorting table, under controlled conditions, were continued. Combinations of 2 flow rates, 4 translation speeds, and 7 potato-rotation rates were used. With a flow rate of $1\frac{1}{2}$ hundredweight per minute, translation speeds of 20 and 30 feet per minute and rotation rates of 1.5 and 1.75 times per foot of translation produced the highest percentages of removal of marked potatoes. At a flow rate of $2\frac{1}{2}$ hundredweight per minute and 10 percent of the potatoes marked to simulate defects, translation speeds of 30 and 40 feet per minute and rotations of 1.0 to 1.75 per foot of translation were most effective. Using the higher flow rate with 20 percent of the potatoes marked, best results were obtained at translation speeds of 40 to 50 feet per minute and rotation rates of 0.5 and 1.0 tuber revolutions per foot of translation. The flow rate had little effect when the sample contained 10 percent marked potatoes, but the high flow rate greatly reduced the removal effectiveness when 20 percent of the sample were marked. Replications with the table width reduced from 24 inches to 16 inches produced increased effectiveness in 6 out of 8 trials.

Tests for bruise resistance of potatoes were made using a special apparatus to obtain consistent impacts on individual potatoes. Results of this year's trials using repeated drops from a selected height until the tuber split can be considered only as preliminary, but indicate some trends and provide guides for future work. Potatoes stored at 38° F. and tested after being in a 50° F. temperature an average of $1\frac{1}{2}$ hour showed a 37 percent increased resistance to bruising. Conversely, potatoes stored at 50° F. and tested after $1\frac{1}{2}$ hour (average) in 38° F. air had a 36 percent decreased resistance. Approximately 75 percent of the potatoes stored at 38° F. and tested in the same atmosphere split with one 9-inch drop of the 0.6 pound weight.

Two manuscripts have been prepared from data previously obtained. "Supplying the Packing Line with Potatoes Stored in Maine Trackside Storages," covers handling methods in use for moving potatoes from storage to the packing line. "Evaluation of a Bulk Railroad Car for Potatoes," reports results of studies of the operation of a rail car conveyORIZED for bulk loading and unloading of potatoes. An article entitled, "Suds Soften Potato-Sponges" was prepared for inclusion in the October 1963 issue of Agricultural Marketing.

2. Gainesville, Fla. This program, carried out in cooperation with the Florida Stations, has as its objective the development of more efficient work methods, operating procedures, and equipment for the handling and preparation for market of potatoes in spring crop areas.

Cost estimates were made in order to compare two experimental handling systems tested with a comparable conventional system for handling potatoes from the field to the packinghouse and holding them temporarily. Information and data from work of previous years were used. The cost estimates

indicate that the bulk dumping system is 16 percent less costly than the conventional system involving the use of hopper-body trucks and sloping-bottom bins, and 19 percent less than the pallet-box system.

In view of these cost relationships and other information relative to the pallet box system, handling work was limited to the experimental bulk dumping operation. An experimental bin used in previous studies was moved to a commercial packinghouse in the Hastings-Elkton area and installed (slope of floor toward main flume was 3 inches in 20 feet as in the previous year), an access ramp of dirt was made, and piping installed to provide water for fluming potatoes from the bin. Tests involved the handling of twenty-four truck loads of potatoes during the season. The weight per load hauled and dumper with the farm-type dump truck ranged from 81 to 88 hundredweight. The method of unloading by dumping entire truckloads is outstanding with respect to the short elapsed time required. Time studies gave essentially the same results as in previous years; two to three minutes per load after adjusting for the experimental nature of the operation. A steady flow of water was provided for fluming potatoes out of the experimental bin, so as to better determine the potential for commercial application of the experimental bin setup. Four different fluming patterns were tested. The pattern which provided satisfactory movement of the potatoes, with minimum effort of the operator handling the hose, was that of working from the front of the bin to the back along one side, and then working out the remainder of the potatoes from back to front along the other side. The rate of output of potatoes from the bin varied from 220 to 510 hundredweight per hour when water flow rates of 150 to 250 gallons per minute were used. In this method, filling the dump truck in the field directly from a mechanical harvester was comparable to the filling of hopper-body trucks used in the conventional system.

The results of evaluations of potato injury agreed with previous evaluations and showed no disadvantage in bulk dumping. Red La Soda potatoes, previously not available for the experimental operations, were among the varieties used in the year's work. No disadvantage was found from the standpoint of potato injury to this variety.

The results of the experimental bulk-dumping operation now provide a basis from which commercial application of the system can be recommended and provides sufficient data for early publication.

3. Red River Valley Potato Research Center, East Grand Forks, Minn. Work is directed toward developing more efficient work methods, techniques, devices, and equipment for the handling and preparation for market midwestern fall-crop potatoes.

Handling.--Work in this area was limited to the further editing of the manuscript and the publication of the report entitled, "Bulk Handling and Shipping Potatoes to Processing Plants." Because of an unfilled vacancy for the one industrial engineer assigned to this work, no additional studies were made of labor and equipment requirements for moving potatoes from storage to the packing line.

Cleaning and Sizing Before Storage.--Norland and Pontiac potatoes were sized directly from bulk trucks into respective 10,000 cwt. capacity, shell ventilated, bulk bins using an expanding pitch, spool sizer. The sizing was done to try and remove all "B" size (under 2 inch) and "Jumbo" size, (over 3½ inch) potatoes before filling the bins. The general size breakdown in the field-run potatoes was 80 percent plus in the "A" size (2 to 3½ inches) and less than 10 percent in each of the respective "B" and "Jumbo" sizes. In samples of potatoes that had been sized into "A" size, the composition ranged from 96 percent "A", 3 percent "B", and 1 percent "Jumbo" to 80 percent "A", 14 percent "B", and 6 percent "Jumbo". Much of this variation can be attributed to variation in potato shape, nonuniform feeding into the sizing rolls and the accumulation of dirt on the sizing rolls.

Market Quality Research Division, AMS, conducted injury studies under a companion project, and found that, although sizing increased bruising about 50 percent, these injuries were mainly non-grade defects. Fifty-pound capacity sample bags were placed at various locations in the bins to measure size change and weight loss during storage. After seven months of storage, the number of "Jumbos" had increased about 1.3 percent, "A's" decreased about 0.6 percent, and "B's" increased about 2.0 percent. Assuming all potatoes were accurately sized into storage, there was not any grade change because of size changes. After seven month's storage, the average weight loss was 4.2 percent with a range of from 3.4 to 5.8 percent. After the potatoes had time to suberize, the average bin temperature was maintained between 34° and 40° F. The greatest temperature difference between any two locations in the potato bin was always less than 4° F.

Originally it was planned to compare the temperature variation in identical bins of sized and field-run potatoes, but during bin filling operations the thermocouple wires were damaged; making this impossible.

4. Moscow, Idaho. The objective of this research was to develop improved methods and equipment for unloading bulk shipments of potatoes from standard refrigerator cars and motortrucks in order to reduce the unit costs of handling and minimize losses from bruising and deterioration.

Under a cooperative agreement with the Idaho Agricultural Experiment Station, a commercially available unit for bulk handling potatoes was acquired, modified, and tested to determine the suitability of the unit for commercial application for unloading bulk shipments.

A test shipment of one car was loaded with an elevating-boom loader which is not now in commercial use. If this equipment were to be made for commercial use, it should be smaller and more maneuverable; about two feet lower and three feet shorter. Cleated rubber belting rather than a potato chain should be used. The boom conveyor also should be telescoping. Self propelled drive wheels would be an added convenience. Although the car actually loaded contained 57,000 pounds of potatoes, an additional 5,000 pounds could have been put in if the loading unit had been equipped with a telescoping boom conveyor. This is a considerably greater amount of potatoes than are shipped in a standard refrigerator car when 100-pound bags are used. A standard load is 450 bags or 45,000 pounds.

The test of the unloading equipment under development was not successful; due primarily to the confined space in a refrigerator car, which hindered the maneuverability of the equipment. The sides and wall of the car held the potatoes in a solid mass so the sides of the nose of the machine functioned as a potato slicer when digging into the pile. In unloading, about 10 percent of the potatoes were severely damaged. With proper modifications this injury might be reduced to a more reasonable figure. Although other problems were encountered, the big one remains the fact that the machine could not be maneuvered inside the car, which means this machine is too inefficient for commercial use. Moreover, a bag car was unloaded in 2 hours by a 3-man crew while the bulk car using a 3-man crew required about 8 hours.

Storage

1. For Table Stock and Seed. Work under this program, at the Red River Valley Potato Research Center, is directed toward providing optimum storage conditions for fall-crop potatoes; and developing improved layouts and designs for potato storage houses, which will permit the use of the most efficient handling and packing methods and keeping injury and mechanical injury to a minimum and minimize construction and maintenance costs.

A revised outline was prepared for rewriting the draft manuscript, "Fall-Crop Potato Storages." When completed this report will include recommendations regarding construction techniques, layout and design, air circulation and ventilation systems, insulation, building materials, and other essentials. Detailed design drawings for a 30,000 cwt. capacity, door-per-bin potato storage was about 75 percent completed. This is the first of four sets of plans which will be prepared for recommended storages. These drawings will contain framing details, floor layouts, air duct systems, ventilation equipment and controls, and flume details.

During the report period, project personnel provided assistance on problems associated with storage construction and regulation, handling, and equipment to approximately 250 firms and individuals.

2. For Processing. Shrinkage and specific gravity data were recorded for Irish Cobbler, Pontiac, Kennebec, and Snowflake potatoes which were stored at 40°, 45°, and 50° F. for processing into flakes and slices. A check lot of each variety was stored in a naturally ventilated alley where the air temperature was allowed to fluctuate as it would in a normal ventilated bin. Potatoes stored at 40° and 45° F. were reconditioned for four weeks at 65° to 70° F. before processing. Potatoes stored at 50° F. were processed directly from storage.

The Chemical Engineering Department, University of North Dakota, processed the potatoes from these storage tests into flakes and slices, evaluated the quality of the final product, and recorded and measured the controlled and uncontrolled process variables. Potatoes were processed at selected intervals from January into August. Because of the uncontrolled process variables (product moisture content, product reducing sugar, and sulfur dioxide in product) no analyses could be made. Flake yield was estimated using specific gravity and shrinkage data. The yield varied from approximately 10 to 17 pounds of flakes per 100 pounds of potatoes placed in storage. There was no consistent relationship between flake yield and storage conditions for each of the varieties. All flakes produced from January into August were of satisfactory quality. The quality of flakes produced in August seemed to be as good as those in January, although the yield decreased because of potato shrinkage.

In the research on storing potatoes for chipping, the effect of different methods of air circulation on the temperature distribution in a bulk pile was investigated. Field-run Irish Cobbler potatoes were stored for chipping in a 6,000 cwt. capacity bin which was divided into four sections. Two sections received shell circulation and two sections received both shell and through circulation. A design air flow rate of 0.67 cubic feet per minute per cwt. was used for each section. Thermocouples were used to record pile temperatures, and sample bags were placed at various locations in the pile to evaluate the shrinkage during storage. CIPC was vaporized into the bin to control external sprouting.

On the average, the combination of shell and through circulation kept the pile about 1° F. warmer than shell circulation alone. The average temperature in the combination shell and through circulation bins was 58° F. After the air had moved up through seven feet of potatoes in the 8-foot pile, there was essentially no difference in the temperatures between the two circulation systems. With a combination of through and shell circulation, shrinkage was 6 percent; with shell circulation it was 4 percent. External sprouting was controlled, but internal sprouting was a problem. Internal sprouting increased from 3 percent during the second week in February to 10 percent by the second week in March, which threw the potatoes out of grade.

Handling and Packing on Terminal Markets

1. Tiering Devices and Equipment. This research also by the Washington office was directed toward reducing the cost of storing fruits and vegetables at the wholesale level by increasing the utilization of available storage space in wholesale fruit and vegetable warehouses.

The manuscript, "Storing Fruits and Vegetables on Pallets in Wholesale Warehouses," was edited for publication and forwarded to the Government Printing Office for printing.

2. Handling Operations for Multiple-Occupancy Facilities. The purpose of this research by the Washington office was to determine the combinations of crew sizes, operating methods, types of handling equipment, stacking or storage patterns, and facility layouts that will minimize the total cost of moving selected volumes of produce into, within, and out of modern multiple-occupancy buildings occupied by wholesale distributors of fruits and vegetables and reduce floor space requirements, and thus provide criteria to TFRD's Marketing Facilities Planning Staff for its work in specific areas or localities.

Work was limited to the completion of a "Survey of Fruit and Vegetable Wholesalers in Multi-Occupancy Facilities," covering 83 dealers in 11 cities in 10 different states. A summary has been prepared of the survey data, which include the business characteristic -- number of store units, annual sales, volume, seasonality of business, inventory, size, hours of operations, and services provide -- customer information -- type of customer, order size, and sale method -- and labor employed -- number of workers, wages paid, hours of work, crew size, and full or part-time workers.

Personnel assigned to this project have transferred and will not be replaced.

3. Loading Out Delivery Trucks. The purpose of this research is to evaluate and compare the relative efficiency of selected methods and types of materials handling equipment for order assembly and truckloading that are used by wholesale distributors of fresh fruits and vegetables supplying both affiliated and non-affiliated retail stores so as to reduce unit costs and minimize spoilage and waste.

This is a joint project of the Handling and Facilities Research Branch and the Wholesaling and Retailing Research Branch. Three basic types of loading out systems were studied in the warehouses of three wholesale distributors. The three methods include the use of: (1) A motorized belt conveyor with recording and transcribing equipment; (2) a motorized belt conveyor and checker system; and (3) a tow tractor and 4-wheel trucks to assemble individual orders. Preliminary analysis shows that the motorized belt conveyor with recorder and transcriber was less costly than other

methods for the assembly of individual orders containing less than 55 packages. This system seems particularly suited for wholesalers supplying hotels, restaurants, institutions, specialty fruit and vegetable stores, and regular retail grocery stores. For wholesalers assembling larger than 55 packages per order, the tow tractors and 4-wheel selector trucks are the less costly. At the end of the year, a manuscript entitled, "An Evaluation of Selected Methods for Loading Out Produce in Wholesale Warehouses," which summarized the results of this research, was in preparation for publication.

Consumer Packages

A report evaluating newly developed consumer packages for perishable early potatoes was published in January. Although prepackaging in the production areas of Alabama and Florida cost from 20 to 70 cents more per 100-pound equivalent than shipping in conventional 50-pound burlap or paper bags, retailers who preferred selling prepackaged produce were willing to pay the difference, often more. Five types of consumer packages were evaluated in comparison with the burlap and multiwall paper bags: 10-pound paper bags with mesh windows; 5- and 10-pound polyethylene film bags; and 5- and 10-pound polyethylene mesh bags. The cost and performance of the bags was determined in 8 packing plants and in 29 test shipments sent to northern markets. Less bruising was found in all the consumer bags than in the 50-pound bags. The 10-pound paper bags turned in the best performance with low cost and superior protection of product, although they did not provide as much visibility of contents as the polyethylene bags. However, the polyethylene bags exposed the potatoes to greening unless care was used in shielding them from too much light. The film bags because of their relatively low moisture-vapor permeability, encouraged the development of decay if the organisms were present but for the same reason they retarded dehydration.

Improved Loading Methods for Potatoes. During FY-63 two additional truck tests were equipped with electronic temperature recording instruments to measure the in-transit cooling rate of bagged potatoes when loaded by the new "air-stacked" loading method which was developed at the outset of this project. This concludes all field work on the project and much of the data have been analyzed and results evaluated. A number of tests were made during three shipping seasons from major producing areas of New Jersey to Florida markets to develop, test and evaluate new loading patterns that would facilitate the movement of air through the load to remove heat and moisture. Loading patterns for 50- to 100-pound bags of potatoes were developed. Test results show that the new patterns are relatively stable in transit and, being made up of continuous longitudinal channels, they provide more effective air circulation through the entire load at no increase in cost or sacrifice in load weight. A thousand copies of the air-stacked loading diagram for the 50-pound units in multi-wall paper bags have been distributed to potato shippers, receivers and truck operators.

A detailed final report is being prepared for review and publication during FY-64.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Storage of Potatoes

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Edgar, A. D. 1963. Engineering Problems of the Potato Industry. Paper presented at a meeting of Minnesota Federation of Engineering Societies, Minneapolis, Minnesota, February 22, 1963.

Yaeger, E. C. 1963. Door "Snugger" Prevents Potato Freeze. Agricultural Marketing, Vol. 8, No. 9, September 1963.

Handling and Packing Fruits and Vegetables on Terminal Markets

Bogardus, R. K. and Lutz, J. M. 1962. Proper Storage Helps Keep That Farm Fresh Quality. SWD Bulletin, United Fresh Fruit and Vegetable Association, No. 228, November 15, 1962.

Bogardus, R. K. 1962. Signposts for Low Cost Handling of Fruits and Vegetables. Agricultural Marketing, Vol. 7, No. 12, December 1962.

Bogardus, R. K. 1963. Crew Organization Saves Dollars. Agricultural Marketing, Vol. 8, No. 2, February 1963.

Bogardus, R. K. 1963. Materials Handling Systems for Terminal Market Wholesalers. Paper presented at the Annual Convention, United Fresh Fruit and Vegetable Association, Los Angeles, California, Feb. 11, 1963.

Potatoes

Ginn, John L., Hale, Philip W., Buxton, Freeman K. and Chapogas, Peter G. 1963. Prepackaging Alabama and Florida Potatoes at Production Point. Marketing Research Report 572, pp. 30.

COOPERATIVE MARKETING

Marketing Division, FCS

Problem: Farmers continue to expand their use of cooperatives in marketing the products of their farms. In light of the rapid and complex changes taking place in technology and in market organization and practices, research is needed to help farmer cooperatives and other marketing agencies perform needed marketing services both more efficiently and more effectively. Farmer-directors, managers and others, including the public, need more information to assist in making decisions on how cooperatives can maintain and strengthen the bargaining power of farmers, increase efficiency and reduce costs of marketing, and better meet the needs of our mass distribution system for large quantities of products on a specification basis.

Farmer cooperatives are an important part of the distribution system and represent a major potential for meeting farmers' marketing problems in our modern, dynamic system. They are organized and operated to increase farmers' net income. However, cooperatives face many problems in achieving this goal. Cooperatives must find ways to consolidate volume, for example, through internal growth, merger, acquisition or federation, to strengthen their market position and meet the needs of mass merchandising. Ways must be found to reduce costs by increasing efficiency through improved operating methods, better organization and management, and more use of new technologies.

USDA PROGRAM

The Department conducts a continuing long-range program of basic and applied research and technical assistance on problems of marketing farm products cooperatively. Studies are made on the organization, operation and role of farmer cooperatives in marketing. While most of the research is done directly with cooperatives, the results are generally of benefit to other marketing firms. The work is centered in Washington, D. C. Many of the studies, however, are done in cooperation with various State Experiment Stations, Extension Services, and Departments of Agriculture.

The number of Federal professional man-years devoted to research in this area totals 21.2, of which 1.0 are on the cooperative marketing of potatoes.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Improving operating methods. To provide guidelines to growers on improved methods of marketing their potatoes, a survey was made of practices and preferences of important wholesale buyers obtaining supplies from the Eastern Shore of Virginia. In preparation is a report covering trends in production, utilization and marketing, characteristics of potatoes and sources of supply desired by buyers, competitive position of the Virginia industry, and recommendations for strengthening this industry. This work is being done jointly with the Virginia State Department of Agriculture.

ECONOMICS OF MARKETING
Marketing Economics Division, ERS

Problem. Most agricultural processing industries are experiencing rapid and drastic changes in their market organization and practices. These changes are affecting both farmers and consumers. Research is needed to keep abreast of such changes and to indicate their probable consequences. There have been substantial advances in recent years in increasing efficiency and reducing costs through adoption of new technology in producing, assembling, processing, and distributing farm products. However, for producers and marketing firms to remain competitive additional information is needed on margins, costs, economics of scale and efficiencies possible in the marketing of farm products.

Marketing research also is increasingly concerned with evaluating present and prospective programs pertaining to agriculture, such as the Food Stamp Program and Federal Grading Activities and to the changing structure of market industries as this may influence the bargaining power of farmers. Research also is being directed to the economics of transportation and storage activities of both private firms and government. Increasing attention is being given to the longer-term outlook for various products and markets as an aid in better assessing the prospects for increasing industrial employment under the Rural Development Program and in assessing prospective interregional shifts in the areas of production and marketing for specific products.

USDA PROGRAM

The Department has a continuing long-term program involving agricultural economists, economists, and personnel with dual economic and technical training engaged in research to determine the reasons for the changes that are taking place in marketing so that ways can be found to increase the efficiency of the marketing system and make it more responsive to changing public needs. This research covers all economic aspects of marketing from the time products leave the farm until they are purchased by ultimate consumers. It includes work on market potentials for new products and uses; merchandising and promotion; economics of transportation and storage; marketing costs, margins and efficiency; market structure, practices and efficiency; and on information, outlook and rural development. In fiscal year 1963, 1.35 Federal professional man-years were utilized in this work on potatoes.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Market Potentials for New Products and UsesLiaison Between ERS and Utilization Research, ARS

An agricultural economist is stationed at each regional Utilization Research and Development Division to provide liaison between the regional laboratories, ARS, and the Economic Research Service in order that economic research may be teamed with physical science research in approaching problems relating to new products and new uses. Phases of work are as follows:

- (1) To delineate the economic problems involved in developing markets for new and extended uses of commodities on which the laboratories are working;
- (2) to develop and assist in carrying out research studies for providing information that would aid the laboratories in deciding what particular products or processes would be most likely to be economically feasible; and
- (3) to develop and assist in carrying out research studies for appraising new products and processes developed by the laboratories, including studies of market potentials, comparative costs, and studies of the probable impact of new developments on sales and farm income.

Merchandising and Promotion

Increased Produce Sales Through Improved Merchandising. Work has been started to review research conducted by the Department and other sources on retail merchandising and promotion of fresh produce. From this review, research findings applicable to improved retailing of produce will be condensed, assembled, and made available to retailers, commodity groups, and others involved in distribution of produce.

Economics of Transportation and Storage

Fruit and Vegetable Transportation. The volume of fresh produce shipped interstate from California-Arizona production areas has remained relatively constant since 1951. Total traffic handled by both railroads and trucks has averaged about 350 thousand carlot equivalents annually. Approximately 60 percent of the interstate shipments from California-Arizona origins moves to destinations east of the Mississippi River. About 32 percent moves to points west of the River, while 8 percent is dispatched to Canada and Mexico. In 1951 rail carriers handled 87 percent of the shipments to United States outlets and 93 percent of the traffic routed to Mexican and Canadian destinations. Since then, rails' share of the annual volume shipped from California and Arizona to interstate markets has dropped to 70 percent and to 81 percent of the movement into Canada and Mexico during 1960. This loss by the railroads to trucks occurred primarily in that traffic moving to points west of the Mississippi River.

The ability of motortrucks to perform multiple pickup and multiple dropoff service, to make faster deliveries, and to offer greater flexibility for

servicing less than truckload consignments were prime factors contributing to their success. Trucks are providing services that rails cannot duplicate economically.

The shipper survey phase of the two-part study is in manuscript form. The receiver phase will follow. Publication of the first phase is expected during the fourth quarter of calendar year 1963. Data are complete for the second phase.

Marketing Costs, Margins and Efficiency

Marketing Margins. Marketing margins, retail prices, and farm values for fresh fruits and vegetables each increased 3 percent from 1961 to 1962. The farmer's share of the retail price for fruits and vegetables remained unchanged at 34 percent. Margins and prices for processed fruits and vegetables decreased. The farm value was down 12 percent, the retail price 4 percent, and the marketing margins 1 percent. The farmer's share of the retail cost dropped from 23 to 21 percent. A study of marketing margins for Washington Delicious Apples sold in Chicago and New York City showed the largest component to be the wholesale-retail margin. This margin claimed from 37 to 54 percent of the retail dollar in Chicago, and from 34 to 48 percent in New York City.

Market Structure, Practices and Competition

Changes in Structure of Wholesale Fruit and Vegetable Markets. Direct buying of fresh fruits and vegetables from shipping points by retail chains, together with increased prepackaging, have had serious effects on the structure of the wholesale market for fresh produce.

A final report summarizing changes in the structure of 52 wholesale produce markets has been completed. Direct purchases from shipping point by chains and affiliated groups increased from 12 percent of total market receipts in 1936 to 26 percent by 1958. During this same period the number of produce wholesalers decreased by 15 percent.

There is a shift toward more specialized markets for fruits and vegetables as reflected by changes in the types of fruit being handled by auctions located in terminal markets and by the increase in consumer packaging. In addition, in the produce industry there is a shift in emphasis from "trading" to "merchandising." Many firms are giving emphasis to performing marketing services contributing to orderly marketing rather than attempting to profit from short-term changes in prices.

Changes in the Structure and Performance of the California Fruit and Vegetable Industry. Changes in the market structure and practices in marketing fruits and vegetables grown in California require producers, shippers and wholesalers to adopt lower cost methods and practices.

Particular attention has been given to an examination of the assembly and distribution of fresh fruits and vegetables including mode of transporta-

tion and composition of shipments. From 1955 to 1961 transportation of fresh fruits and vegetables shipped out of California by truck increased from 20 to 30 percent of the total volume. In 1961, shipments in mixed loads accounted for 65 percent of all trucks inspected at border stations--averaging 5.5 different commodities per load.

Marketing Agreements and Orders. While Federal market order programs have operated for many years, little economic analysis of their operations or results has been made. Guides are needed for determination of the usefulness and probable effects of selected market order provisions for various commodities and marketing conditions.

Activity has been confined to preliminary investigations with respect to the five currently active Irish potato orders, the date order, and the suspended Florida tomato order. Questionnaires have been prepared for interviews of potato and data market order managers and administrative committee members and a sample of Florida tomato producers and handlers. Available secondary data concerning the potato and date orders are being studied.

Structure of the Red River Valley Potato Market. The purpose of this new project is to evaluate the structure and performance of the market for potatoes in the Red River Valley producing area. Primary attention is being given to those factors affecting prices and price variations and to the impacts of potato processing plants on the industry in the Valley. Detailed plans for the study have been made, but research results are not now available. This project will utilize the results of a similar project in the Idaho producing area, results of which were previously reported.

Information, Outlook and Rural Development

First Phase of Long-Term Outlook for Marketing Western Agricultural Products Relates to Fruits and Vegetables

Outlook for the marketing of fruits and vegetables for the 11 Western States was projected for the period 1975. These projections show a continued growth in the volume of these products and indicate that this western region should supply an increasing share of the total. The forecast is based on an expected increase of 31 percent in total U.S. population and some increase in per capita consumption per year. The West now supplies about 65 percent of noncitrus fruit, 45 percent of vegetables, and 28 percent of citrus fruits. Increases in the proportion of total supply of noncitrus fruits and vegetables, with a small decrease in the proportionate citrus fruits supplied by the West, appear in prospect. These changes can be viewed in terms of the total U.S. consumption increase projected for the period of approximately 33 percent above that of 1960.

The greatest growth including vegetable sales appears to be in processed products. The greatest growth in food and vegetable processing between now and 1975 is likely to be in freezing, combined freezing and dehy-

dration, and various improved methods of dehydration. In these areas processing has grown rapidly and is likely to continue to grow for the next several years, though possibly at a slower rate.

Long-Term Outlook for Industries Assembling and Processing Products
of Agriculture in the Pacific Northwest

This research, by five-year periods between 1965 and 1980, will project the production and employment in establishments assembling and manufacturing products of agriculture. The geographical area covered will include the States of Washington, Oregon, Idaho, and western Montana. Projections for the statistical base period (1965) are near completion.

During the coming year extensive progress is anticipated in completing the series of five-year projections.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Marketing Costs, Margins and Efficiency

Edman, Victor G. February 1963. Marketing margins for fruits and vegetables. Article in Marketing and Transportation Situation. (Reprinted as ERS-106.)

Market Structure, Practices and Competition

Bohall, Robert W. April 1963. The organization of the wholesale fruit and vegetable markets in Miami and Tampa-St. Petersburg. MRR-593.

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Information, Outlook and Rural Development

Martin, Loyd C. February 1963. Role of processing in utilizing all grades of products. Remarks at the Joint Session of Marketing and Horticulture Sections of the Association of Southern Agricultural Workers, Memphis, Tennessee.

Stallings, Dale G. March 1963. Marketing western fruits and vegetables, long-term outlook. ERS-77.

ECONOMIC AND STATISTICAL ANALYSIS
Economic and Statistical Analysis Division, ERS

Problem. Because of the instability of the prices he receives and rapidly changing conditions of agricultural production, the farmer stands in special need of accurate appraisals of his economic prospects if he is to plan and carry out his production and marketing activities in an efficient and profitable way. The typical farmer cannot afford to collect and analyze all the statistical and economic information necessary for sound production and marketing decisions. It has long been a goal of the Department to provide the farmer with economic facts and interpretations comparable to those available to business and industry, through a continuous flow of current outlook information; the development of longer range projections of the economic prospects for the principal agricultural commodities; and analyses of the economic implications of existing and proposed programs affecting the principal farm commodities.

Producers, processors, distributors and consumers need better information on the supplies, production and consumption of farm products, and the effect of these and other factors on the prices of these products. Similarly, Congress and the administrators of farm programs need to evaluate alternative proposals to modify existing price support and production control programs in terms of their impact on production, consumption and prices received by farmers.

USDA PROGRAM

Commodity Situation and Outlook Analysis

This work involves 0.5 professional man-year in Washington. The outlook and situation program provides a continuing appraisal of the current and prospective economic situation of potatoes. Results of these appraisals, developments of interest to the industry, findings of special studies, and long-time series of basic data are published in quarterly issues of the Vegetable Situation, the National Food Situation, the Demand and Price Situation, and monthly in the Farm Index. A comprehensive analysis of the potato situation is presented at the Annual Outlook Conference. Presentations also are made at regional or State outlook meetings, at meetings of farm organizations, and to various agricultural industry groups. Special studies are made from time to time to determine the effect of current programs and the probable effect of proposed programs on supply, price and utilization of potatoes. Basic statistical series are compiled, improved and maintained for use in statistical and economic analysis.

Supply, Demand and Price Analysis

This work involves 0.5 professional man-year located in Washington, D. C., making separate analyses for the total U.S. crop, the various seasonal crops, and the major producing areas. These analyses measure the effect of price and other factors on acreage and production of

potatoes; the effect of supplies and other factors on price and utilization of potatoes; the effect of price, income and other factors on consumption; and the effect of price and other factors on storage demand and level of storage.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Commodity Situation and Outlook Analysis

Overall supplies of potatoes were a little smaller in the fall and winter of 1962-63 than a year earlier, and prices to growers averaged substantially above the depressed levels of the previous fall and winter. In the spring of 1963, however, production was larger than in 1962, there was some bunching of marketing of old crop and new crop potatoes, and prices averaged below those of a year earlier. The late summer and fall crops, combined, are a little smaller than last year, although larger than needed, and prices in late summer are above year-earlier levels. About 3.3 million hundredweight of U.S. No. 2 or better grade potatoes from the 1962 crop were diverted to starch or livestock feed, under the USDA diversion program. Over 19 million hundredweight were diverted from the 1961 crop, when average prices to growers were extremely low.

During the past year the commodity specialist continued to serve as Economic Advisor to the National Potato Advisory Committee. Considerable time and effort were devoted to special appraisals of the influence of present and proposed potato programs on production, price and income. Long-run (5 year) projections of supply and utilization were made for potatoes as part of a set of ERS projections for the economy as a whole.

Supply, Demand and Price Analysis

Several previously completed demand analyses as part of a technical bulletin were updated and others varied to take into account changes in recent years. In addition, a separate study was made of the impact on total consumption of the rapid increase in consumption of processed potato products. In the last six years, use of processed potato products increased 14 pounds per person, more than enough to offset the use of fresh potatoes which declined 4.8 pounds. The increase is greater than could normally be attributable to changes in relative prices and income, indicating an increasing preference for processed potato products. Market acceptance for processed potato products reflects the increasing preference by consumers for convenience type foods. Separate demands exist for potatoes used for food, for feed and for starch. Results from statistical analyses indicate that the price elasticities of demand were around -0.05 to -0.10 for food use, around -0.25 for livestock feed, and about -1.2 for starch.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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Supply, Demand and Price Analysis

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